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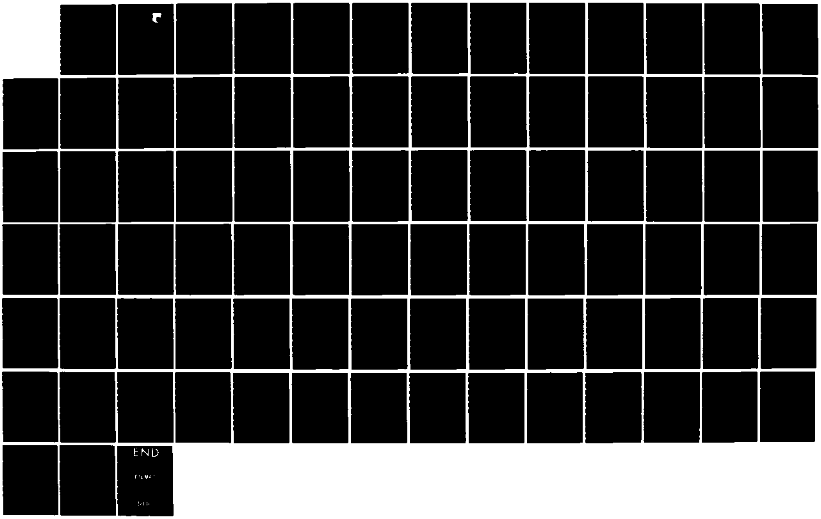

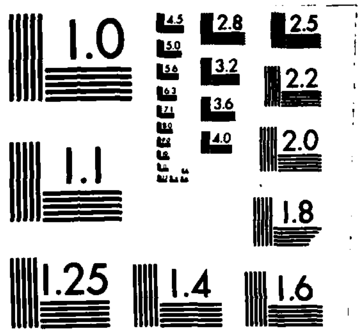
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AFWAL-TR-84-4069
Volume I

AD-A155 817

BENEFITS ANALYSIS OF PAST PROJECTS

Volume I: Summary Report

Applied Concepts Corporation
109K North Main Street
Woodstock, Virginia 22664

May 1984

Final Report for Period April 1982 — January 1984

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This technical report has been reviewed and is approved for publication.

WILLIAM J. SCHULZ

FOR THE COMMANDER

GARY L. DENMAN
Director
Manufacturing Technology Division

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A program was conducted to assess the technical results, degree of implementation, and resulting benefits from 75 past Air Force MANTECH projects. The projects encompassed nineteen divisions of eight major aerospace contractors, and most types of USAF end items.

Almost one-half ~~(47%)~~ of all projects led to production implementation, yielding over $992 million ~~(in 1982 dollars)~~ in projected manufacturing cost savings through 1992, under a peacetime scenario. The savings figures are conservative in that they reflect only actual or definitely programmed cases of implementation, for implementation only at the contractor that performed the project, and reflect manufacturing cost only, exclusive of IR&D, G&A, and profit loadings.

Approximately $593 million (60%) was in savings on military items, and $399 million (40%) was in production of commercial items. The Air Force portion of the military savings

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was approximately $522 million (88%). The bulk of the commercial savings resulted from employment of MANTECH-developed technologies by General Electric and Pratt & Whitney Aircraft for production of commercial aircraft engines.

The savings-to-cost ratio for all projects and all economic benefits was found to be 19:1. Considering savings only to the military, the savings-to-cost ratio was 11:1, and from the perspective of the Air Force alone, 10:1. The savings figures and ratios do not include numerous non-economic benefits which were identified. Many of these were product quality improvements which resulted in more mission-effective end items.

Several recommendations were made for enhancing the likelihood that MANTECH projects will lead to implementation and generate economic and other benefits.

FOREWORD

This is the final, comprehensive technical report on work performed under Contract F33615-81-C-5145, "Benefits Analysis of Past Projects." It provides a summary analysis of all MANTECH projects and contractors assessed under this contract. The results of the individual project assessments are presented under separate cover in Volume II.

The work reported herein was performed by Applied Concepts Corporation of Woodstock, Virginia and Berthoud, Colorado for the Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio. Mr. William Schultz was the Project Engineer for the Manufacturing Technology Division. Mr. James A. Simpson, Applied Concepts' Program Manager, and Mr. Robert L. Uphoff were the authors of this report. Mr. Stanley L. Pond and Mr. J. Scott Hauger contributed to the technical work.

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I. INTRODUCTION

A. Background to the MANTECH Program

Since the 1960's, the annual rate of growth of manufacturing productivity in the United States has lagged behind that of most other industrialized countries. According to the Bureau of Labor Statistics, growth of real output per employee engaged in manufacturing in the U.S. remained essentially flat over the decade of the seventies. This lag in productivity growth has been a matter of growing concern to the Congress and Federal executive agencies. In order to remain internationally competitive, reduce inflation, and maintain a strong industrial base, improving manufacturing productivity has become a national priority.

Continuously faced with a limited budget, increasing equipment requirements, and increasing acquisition costs, DOD initiated the Manufacturing Technology Program (MANTECH) to help improve manufacturing productivity in the defense industrial base. MANTECH objectives are to develop and improve manufacturing processes, techniques, materials, and equipment in order to provide timely, reliable, and economical production of defense equipment. The program is designed to bridge the gap between R&D innovation and full-scale production implementation. MANTECH projects are conducted after preliminary research work has been accomplished and the feasibility of the innovation demonstrated in a laboratory or other "sympathetic" environment. MANTECH projects are designed to demonstrate that R&D innovations can be employed under actual factory working conditions for more efficient production of actual defense equipment.

The MANTECH program can be viewed as an investment program, providing seed money to reduce future hardware costs or to enhance its mission effectiveness. MANTECH funds an initial demonstration of the new or improved manufacturing technology, with the expectation that if it is successful industry will follow through and implement the technology for production. The MANTECH program works by reducing the sizable risks inherent in introducing into production new, unproven processes and equipment. By lowering these risks, it stimulates and accelerates the implementation of improved manufacturing technology. The program payoffs may be realized in the form of: lower unit production cost; lower product life cycle cost; shorter production lead time; or a qualitatively superior and thus more mission-effective product.

The Air Force was the first military department to actively support the development of improved manufacturing techniques. The USAF program for improving manufacturing techniques in the aerospace industry dates back to the late 1940's. The Army began a similar program in 1964, and the Navy in the late 1960's. The DOD Manufacturing Technology (MANTECH) Program was formally established in 1968.

B. Background to This Project

In early 1979, the General Accounting Office (GAO) conducted a review of the DOD MANTECH program. One of their findings concerned the need for the Military Departments to strengthen their procedures for tracking the implementation of project results and for documenting the benefits of the program. To accomplish this, the Air Force as of FY81 has included in the statement of work of all its MANTECH contracts a requirement for the tracking of implementation, benefits, and technology transfer. To establish an analytical baseline for understanding MANTECH benefits, USAF sought an independent, outside contractor to consider benefits resulting from contracts awarded prior to 1981. This is the objective of the "Benefits Analysis of Past Projects" contract, which was awarded to Applied Concepts Corporation on April 3, 1982, and for which this report is a deliverable. The Air Force originally designated 77 completed MANTECH projects at nine contractors for assessment of resulting implementation and benefits. The scope of the program subsequently was reduced slightly, to 75 contracts at eight contractors. Figure 1 presents the contractors included in the program and the number of contracts assessed at each. The program was organized into a Basic Option and five additional Options, as indicated in Figure 1. Figure 2 presents the number of contracts by application area.

Interim reports were delivered on the Basic Option and Options 1 through 4. The interim reports presented the results of the contract- and contractor-specific assessments. This final, comprehensive report is the deliverable for Option 5. It provides a summary analysis of all contracts and contractors, and presents "lessons learned" and recommendations for enhancing implementation and program benefits. An additional task to assess possible strategies for tracking and reporting MANTECH program benefits over time was added to the benefits analysis program. The report on this additional task is included as the last chapter of this document. The results of the individual project assessments are presented in Volume II.

Option	Contractor	# Contracts
Basic Option	General Electric	14
Option 1	Pratt & Whitney Aircraft	13
Option 2	General Dynamics	8
	Rockwell International	10
Option 3	McDonnell-Douglas	10
	Northrop	6
Option 4	Boeing	9
	Hughes Aircraft	5
Option 5	Summary Assessment and Report on All Contracts at All Eight Contractors	75

FIGURE 1: Contractors and Number of Contracts

Airframes	34
Engines	23
Electronics	11
Rockets/Missiles/RVs	6
Munitions	1

FIGURE 2: Application Areas of Contracts Assessed

II. METHODOLOGY

A. Summary of the Methodology

The project team worked with each contractor to accomplish the following tasks, in the approximate order listed below:

1. Determine the degree of technical success of each project.

2. For technically successful projects, determine the general nature and extent of implementation or other follow through.

3. Determine why successful projects have not led to implementation or other follow through.

4. For implemented technologies, identify their specific applications (i.e. components, aircraft, etc.), denoting where the technology has already been implemented, where it is programmed for implementation, and where it has longer-term potential.

5. For each case of actual or programmed implementation, identify and quantify the resulting savings and other benefits (e.g. number of labor hours, pounds of input material, equipment requirements, throughput increases, component weight savings, performance, efficiency, etc.).

6. Develop monetary estimates of the above savings, where possible.

7. Summarize the findings for each contractor (presented in interim reports).

8. Summarize the findings across all contractors. Assess degree of technology transfer. Identify "lessons learned", and make recommendations for enhancing program benefits.

B. Detailed Approach

Both monetary and non-monetary benefits were identified. For the purposes of this project, a "monetary benefit" is defined as:

> A decrease in the cost of production, maintenance, repair, or operation resulting from the use of manufacturing technology which, as evidenced by the assessed contracts, the USAF MANTECH program played a contributing developmental role.

Manufacturing monetary benefits are expressed in terms of manufacturing cost savings, and do not include General and Administrative (G&A), Internal Research and Development (IR&D), or Fee loadings. They encompass all direct and indirect manufacturing costs, including all manufacturing overhead and burden, or purchase price if vendor-supplied.

There is already an Air Force and DoD program that is designed to meet the objectives stated above. This is the Technology Modernization (Tech Mod)/Industrial Modernization Improvement Program (IMIP). This program provides investment incentives through retained productivity savings or through indemnification protection. Retained productivity savings provide a monetary incentive to motivate contractor investment in new equipment, over and above its normal capital improvement program. Indemnification protection provides for government purchase of equipment or other compensation if projected procurement volumes are not made.

Unfortunately, the implementation opportunity for most of the assessed projects preceded the Tech Mod/IMIP program, and the benefits anlysis program could not assess the effectiveness of Tech Mod/IMIP in overcoming the financial and risk barriers to implementation. However, the seven cases of lack of implementation due to inadequate financial returns provide some documentation of the need for this program. On the other hand, the results show that even without the Tech Mod program, the majority (61%) of technically successful projects were implemented anyway. This high rate of implementation occurred without a quick return. Certainly few, perhaps none, of the 35 cases of implementation paid back within one year.

With $992 million in manufacturing cost savings from 35 cases of implementation identified in this program, it is certain that MANTECH-supported technologies are being implemented and are yielding extremely large manufacturing cost savings, most of which accrue to the government. Given the lack of near-term financial incentives for contractor implementation, and without a Tech Mod program to support the implementation of these technologies, the question then becomes why the contractors chose to implement them.

We have concluded that the driving force behind implementation at these firms is the maintenance of their competitive position over time, and not direct, near-term economic benefits. This is based upon two sources of information. First, very few if any of the 35 implemented projects were cases of extremely high short-term payoff. Thus, most were implemented with the contractor knowing full well that the government, and not it, would actually receive the bulk of the savings. Secondly, we interviewed numerous managers and executives in the eight companies and nineteen company divisions with which we worked. We knew coming into this program that product technology has traditionally been the key to success in the defense aerospace business. We have learned in the performance of this program that top management at defense aerospace firms increasingly perceive their manufacturing technology to be as important as their product technology. Efficient, state-of-the-art manufacturing capability, with state-of-the-art efficiencies and state-of-the-art costs, is thought now to be essential for winning the large and lucrative production contracts on which company profitability, and ultimately company survival, depend. Also, there is a strong perception that over time enhanced manufacturing capability opens the door for product improvements, because the design and characteristics of a product are inherently constrained by the manufacturing processes available to produce it.

IV. LESSONS LEARNED AND RECOMMENDATIONS

The performance of this benefits analysis program has led to a number of important lessons learned and recommendations for MANTECH program management. These are presented below.

A. Lack of Financial Incentives for Implementation

Near-term financial incentives for contractor implementation of MANTECH-supported technology and new manufacturing technology in general are weak, perhaps negative. Most, if not all, of the military end items analyzed in this benefits analysis program are typical in that they are procured under negotiated contract procedures, where prices are negotiated based upon projected manufacturing cost. Under this type of acquisition process, prices are negotiated for each separate procurement, which occur periodically, typically annually. The result of this type of acquisition approach is that cost savings from implementation of new manufacturing technology accrue to the contractor for a very short period. When implementation of a new process reduces the manufacturing cost of an item, the contractor can be sure that at the time of the next procurement, these savings will be transferred to the Air Force in the form of a reduced price. Since profits typically are directly related to costs, lower costs ultimately reduce company profits. This is hardly an incentive for implementing cost reducing manufacturing technologies.

The result of this situation is that substantial, direct financial incentives exist only for manufacturing methods and technologies that pay back very quickly. Since most advanced manufacturing technologies, particularly highly automated ones, are characterized by very high equipment and other high initial costs and seldom have less than a one year payback period, this situation has major negative implications for implementation of advanced manufacturing technologies.

In addition to the lack of financial incentives, the high degree of uncertainty associated with defense sales also tends to impede implementation of expensive new manufacturing technology, no matter how efficient or cost-effective it may be. The government's practice of acquiring end item quantities by annual increments means that a contractor cannot be sure that anticipated program quantities will actually be realized, or if so that it will win the business.

Financial incentives which would enable contractors to recoup their investment costs over a longer time period, and thus a larger production volume, or USAF assurance of a longer-term production requirement, would enhance the rate of implementation. A program allowing extended capture of savings by contractors, or a program of shared savings, would have very desireable impacts on MANTECH implementation. Also, indemnification protection regarding procurement volume would help enhance the rate of implementation. This would provide that a stated minimum number of items would be acquired by the government, thereby assuring amortization of investment expenditures.

D. Analysis of Time-To-Implementation

The average time-to-implementation for implemented projects is presented by contractor and by end item in Figures 3 and 4 respectively. The averages range from zero years to 7.3 years. The highly variable average time-to-implementation reflects two circumstances that varied greatly at the conclusion of a technically successful MANTECH project. First, the level of effort required to prepare for implementation varied greatly across these new manufacturing technologies. Some were ready to implement immediately and, indeed, some were implemented even before the project was completed. Others still needed more work to refine the technology and get it 100% ready for production, particularly for the specific components to be produced. Secondly, and probably more importantly, the wide variation in implementation time reflects the timing of production application opportunities, which in turn is driven by the timing of Air Force or other procurement of the end items. Thus, the longer times-to-implementation often reflect the time between the end of the MANTECH project and a procurement (production) decision by the Air Force, and not the time required to prepare the technology for production.

# Projects Technically Successful, But Not Implemented	22
• Not Cost Effective	8
• Eclipsed By An Alternate Technology	7
• Lack of An Application	4
• High Technical Risk Remained, More Follow-on Work Required	2
• Lack of Product Demand & Sharp Price Drop by Another Supplier	1
• Info on Implementation Unavailable, Presumed Not Implemented, Reason Unknown	2
• Good Future Potential Remains	8

*Total number of reasons is greater than number of projects because more than one reason can apply to a single project.

Figure 6:
Reasons For Lack of Implementation of Technically Successful Projects*

3. Manufacture of engine components entails a higher value added per pound of material, and thus offers inherently more opportunity for manufacturing cost reductions.

4. It may be that competitive forces affecting the engine companies tend to make them more aggressive in introducing new, more efficient and more economical manufacturing technology.

5. Lastly, even though the size of the sample of engine and airframe projects assessed was rather large (23 and 34 projects, respectively), sample bias may partially explain the results.

The key finding regarding electronics projects is that they had a very high technical success rate (91%), but a rather lackluster rate of implementation for the technical successes (50%). The rather low implementation percentage is due to the dynamic nature of the end item technology and the manufacturing processes to produce them. The electronic technologies are changing very rapidly, leading to very rapid technological obsolescence--for both manufacturing process and end item. The rather substantial dollar savings and savings-to-cost ratio are somewhat surprising since the main objective of many electronics projects was technical (i.e. mission related), and not cost.

The missile/RV area also is characterized by mission, not cost, objectives. It is also characterized by rather high technological risk. These facts are reflected in this category's 50% technical success rate, and the zero dollar savings from the implementation that occurred.

C. Analysis of Technically Successful Projects Which Were Not Implemented

Twenty-two projects were classified as technically successful but not implemented. Appendix B is a summary by contractor of the reasons why each of these projects was not implemented. Figure 6 presents a breakdown of the reasons given by contractors for why they were not implemented. Since multiple reasons were given for many cases, the number of reasons is greater than 22.

Lack of cost effectiveness and being eclipsed by an alternate technology were the two reasons given most often, with eight and seven cases respectively. Four projects suffered from lack of a suitable application, and two needed further work to reduce technical risks before implementation could be considered. There was one case where the objective was to establish a domestic source, which was accomplished, but a drop in product demand and a sharp price reduction by the foreign supplier subsequent to the project led to continued USAF procurement from the foreign supplier. There were two projects that were judged technically successful for which we were unable to determine if implementation had occurred. These were conservatively presumed to have not been implemented, with the reasons unknown.

Of the 22 technically successful but not implemented projects, eight are thought to have good potential for implementation in the future.

fundamentally new and different materials and processes. Many airframe projects involved movement from metals to non-metal or composite metal materials, which is inherently higher risk than working within a familiar metals environment.

Also, the lower rate of implementation for airframes must be considerd in the context of the available end item applications. Only two new airframe application opportunities arose (the B-1B and F-18) during the timeframe encompassed by the selected sample of projects. There were over ten new or modified engines whose production was initiated during this time period. The likelihood of a new manufacturing technology being cost effective and being implemented is much higher if it can be introduced initially at production start up, and does not have to recoup the tooling and other "sunk" costs of an existing production capability.

Savings from the set of airframe projects will expand in the future as production of new generation aircraft takes place. For example, we understand that most contractors will propose advanced integral composite structures in their designs for the Advanced Tactical Fighter. In the one USAF airframe opportunity that arose during this period (the B-1B), substantial implementation and savings were in fact realized. Of course, new engines introduced in the late 1980s and early 1990s can also be expected to utilize many of the new manufacturing technologies that were established in the propulsion projects.

It must also be considered that production quantities for engine components, and therefore the opportunity to translate per part savings into large dollar amounts, are significantly higher than for airframes. Most USAF aircraft have multiple engines, with a substantial spares requirement, and numerous engine parts are replaced over an engine's service life. Engines also present major opportunities for repair cost savings. Airframe components offer much less opportunity for replacement and repair cost savings.

In addition to the known factors mentioned above, there are a number of other possible explanations for the superior propulsion results. These are presented below for consideration, and not as conclusions.

1. Engine technologies may be inherently easier to implement than those for airframes. Engines typically are somewhat modular, with more repetitive use of individual components. It may be that for engines, manufacturing technology developed for a single component is more transferable to other components than for airframes. It may be easier to substitute improved components into an engine than an airframe, because improvements can be made more incrementally in an engine, without making fundamental changes in the end item itself.

2. It may be easier to justify introduction of new technology onto the shop floor for engine production, because production equipment for airframes is more special purpose, and present a higher sunk cost that must be overcome before manufacturing process changes will be cost-effective.

	# Projects	Nominal Cost	Cost in 1982$	# Tech Successful	# Impl	# Impl with $ Savings	Savings ($ Millions)
Propulsion							
GE	10	4.551	7.128	9	7	6	326.6
P&WA	13	5.130	8.693	11	9	8	434.7
Total	23	9.681	15.821	20	16	14	761.3
Airframe							
GD	8	2.876	4.775	5	2	2	62.1
RI	7	3.573	5.548	5	4	4	51.8
MD	6	2.523	4.112	3	2	2	20.3
Northrop	5	2.142	3.376	4	2	2	30.0
Boeing	8	2.598	4.265	5	2	2	.4
Totals	34	13.712	22.076	22	12	12	164.6
Electronics							
GE	2	2.009	3.253	2	1	0	.0
RI	1	.265	.482	1	0	0	.0
MD	1	.305	.485	1	1	0	.0
Northrop	1	.616	1.122	1	1	1	49.4
Boeing	1	.330	.496	1	0	0	.0
Hughes	5	2.520	4.083	4	2	2	17.1
Totals	11	6.045	9.921	10	5	3	66.5
Missiles, RV's							
GE	2	.916	1.456	2	2	0	.0
RI	1	.244	.387	1	0	0	.0
MD	3	1.495	2.276	1	0	0	.0
Totals	6	2.655	4.119	5	2	0	.0
Gun Propellants							
RI	1	.492	.738	1	0	0	.0
Grand Total	**75**	**32.585**	**52.675**	**57**	**35**	**29**	**992.4**

Figure 5:
MANTECH Summary Report - By End Item
(All $ are in 1982$, in $1,000,000s, except where noted otherwise)

	Propulsion	Airframes	Electronics	Missile RVs	Gun Propellants	All End Items
#Projects Assessed	23	34	11	6	1	75
% of All Projects Technically Successfully	87	65	91	50	0	76
% of All Projects Implemented	70	35	45	33	0	47
% of All Projects Impl w/Savings	61	35	27	0	0	39
% of All Tech Successful Projects Implemented	80	55	50	67	-	61
% of All Implemented Projects Yielding $ Savings	88	100	60	0	-	83
Avg $ Savings Per Project (in $1,000,000s; 1982$)	33.1	4.8	6.0	.0	.0	13.2
Avg $ Savings Per Implemented Project (in $1,000,000s; 1982$)	47.6	13.7	13.3	.0	-	28.4
Avg Time to Implementation for Implemented Projects (Yrs)	3.4	3.8	2.8	.5	-	3.3
Savings-to-Cost Ratio	**48:1**	**7:1**	**7:1**	**0**	**0**	**19:1**

Figure 4: Implementation Summary By End Item

Company	# Projects	Project* Cost	Avg Time to Impl	MC Savings USAF End Items	MC Savings All Military End Items	MC Savings Commercial End Items	MC Savings Total
General Electric	14	7.476* 11.837	2.6 Yrs	46.1	74.0	252.6	$326.6
Pratt & Whitney	13	5.131* 8.693	3.8 Yrs	252.8	288.0	146.5	$434.7
General Dynamics	8	2.876* 4.775	0.0 Yrs	62.1	62.1	-	$ 62.1
Rockwell Int'l	10	4.754* 7.155	5.5 Yrs	51.8	51.8	-	$ 51.8
McDonnell Douglas	10	4.323* 6.873	0.3 Yrs	20.3	20.3	-	$ 20.3
Northrop	6	2.758* 4.498	7.3 Yrs	79.4	79.4	-	$ 79.4
Boeing	9	2.928* 4.761	4.0 Yrs	-	-	.35	$ .35
Hughes	5	2.520* 4.083	1.0 Yrs	9.58	17.13	-	$ 17.13
Total	**75**	**32.586*** **52.675**	**3.3 Yrs**	**522.08**	**592.93**	**399.45**	**$992.38**
Savings to Cost Ratio				**10:1**	**11:1**	**8:1**	**19:1**

*Upper number is actual (nominal) dollars.
Lower number is adjusted to 1982 dollars.

Figure 3:
MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF RESULTS

All $ are in 1982$, in $1,000,000s, except where noted otherwise

III. SUMMARY OF FINDINGS

A. Synopsis

A total of \$ 992.38 million in manufacturing cost savings was identified. \$ 592.93 million of this (60%) was in savings on military items, and \$ 399.45 million (40%) was in commercial items. The Air Force portion of the military savings was \$ 522.08 million (88%). The bulk of the commercial savings resulted from employment of MANTECH-developed technologies by General Electric and Pratt & Whitney Aircraft for production of engines for commercial aircraft.

The savings-to-cost ratio for all projects and all benefits was found to be 19:1. Considering only savings to the military, the savings-to-cost ratio was 11:1, and from the perspective of the Air Force alone, 10:1. Figure 3 presents a summary of the savings, by contractor.

B. Analysis by End Item

Figures 4 and 5 summarize the project findings by end item. The propulsion area had by far the highest implementation rate and the highest economic payoff. Propulsion end items accounted for approximately 77% of all cost savings. Propulsion had a very high technical success rate (87%), a high rate of implementation of technically sucessfull projects (80%), and a very large average savings per implemented project (\$ 47.6 million). The overall savings-to-cost ratio for the propulsion projects was an astonishing 48:1.

Airframes had a lower technical sucess rate (65%), a lower implementation rate for technically successful projects (55%), and a lower (but still substantial) average savings per implemented project (\$ 13.7 million). The overall savings-to-cost ratio for airframes was 7:1.

The electronics projects had the highest technical success rate (91%), but a rather low rate of implementation for technically successful projects (50%). For electronics, average savings per implemented project was \$ 13.3 million, with an overall savings-to-cost ratio of 7:1.

Missiles/RVs had a 50% technical success rate, and an implementation rate of 67% for technically successful projects. None of the implementations yielded cost savings.

There are numerous factors that explain the above findings. The high success and implementation rates and high payoff of propulsion, as compared to airframes, is considered first.

Probably the most important factor in explaining these results is the fact that the propulsion projects tended to work on the edge of rather well known technologies, while the airframe projects tended to involve

importantly, the savings figures reflect only implementaton at the contractor which performed the MANTECH project. Savings from broader implementation were not identified.

There are additional factors that give the savings estimates a conservative bias. Savings were assumed to begin in the year after implementation. To provide a standard basis for all firms, cost savings estimates in pre-1982 dollars were escalated using the Implicit Price Deflator for GNP. Escalation of manufacturing costs in the firms and factories analyzed here has probably been greater than reflected in this figure. The program focused upon identification of manufacturing cost savings. There were many cases where life cycle cost savings were expected but could not be predicted due to inadequate data.

The cost savings figures are also conservative in that they do not reflect the enhanced technical knowledge and capabilities which result from these projects and which are applied over and over again through the years by contractor staff to develop and implement improved, more efficient manufacturing technologies. They do not reflect the long-term benefits from helping to maintain and nurture organizatons inside the contractor companies that are advocates for the continual development and implementation of new, more efficient manufacturing technology. They do not reflect the benefits from helping to keep contractors' internal research and development efforts going in manufacturing technology areas that are of major importance to the Air Force and which may have high but not immediate payoff.

selling prices would be even higher, since the savings estimates do not include G&A, IR&D, or profit loadings. Due to the nature of the acquisition process, it is reasonable to assume that most of the identified savings in military applications are captured by the government, and not the implementing contractor. The savings figures that are presented are savings in manufacturing costs (MC). We beleve MC savings most closely reflect the amounts saved by the government.

Estimating the cost impacts of the MANTECH-supported technologies within the complex and dynamic manufacturing environment is a very difficult task, requiring the exercise of considerable professional judgement. Cost impacts must be factored out of oftentimes complex, interactive changes in: part design; materials employed; downstream and upstream processes; unit prices of labor, material, and equipment; production quantities; and other factors. The difficulties were compounded by the necessity to make maximum use of existing data, most of which had been generated with other objectives in mind. The imprecision inherent in the cost savings estimates should be recognized.

The dollar savings estimates that are presented are net of implementation cost, but they are not net of technology development cost. The total cost of technology development is always substantially higher than the cost of the MANTECH program that was assessed. In many cases, there have been other externally funded research or development programs--through the Air Force, Navy, NASA, and/or other sources--that also contributed to the success of the technology. These have occurred both prior to and subsequent to the specific projects assessed in this effort. There were sometimes follow-on MANTECH projects, and the project under assessment was sometimes a direct follow-on to a previous MANTECH effort. Furthermore, in most cases of implementation the contractor expended considerable company funds, over a number of years, to develop the technology and to get it ready for implementation.

Notwithstanding the inherent imprecision in the cost savings estimates, and the above caveats, it is certain that the figures presented in this report are conservative estimates of overall dollar benefits. In fact, they should be considered lower bound estimates. As mentioned earlier in this chapter, only actual or programmed cases of implementation, with readily trackable savings, were included. Excluded are a host of applications where implementation will probably ultimately occur, but the timeframe is unclear and the savings, though positive, are unquantifiable at this time. Excluded also are many more cases of potential implementation over the long-term, especially as the next generation of engines, aircraft, etc. are designed from the beginning to utilize these new technologies. For some contractors, there were cases of ongoing or very recent implementation where there was not enough process experience to legitimately estimate savings. There were cases where implementation has been too extensive to fully assess all the savings and only a small sample of applications could be costed out, giving only the "tip-of-the-iceberg" of the savings. There were cases where slightly different processes have spun off from the MANTECH process, which were not costed out. Perhaps most

contractors, and to accomplish the work with available project resources, maximum practical use was made of existing information. Therefore, the component, work-station, and other cost savings were not assessed and reported in a standard format. Making maximum practical use of existing data usually meant using it in whatever form it was generated. The existing data was often in the form of internal contractor cost analyses conducted before, during, or after implementation of the new process, or vendor quotes or estimates that had been retained. For each specific application, the approach used to estimate its cost savings was documented. Also, the nature of the cost savings was reported for each application, either in terms of manufacturing inputs (e.g. labor, material, consumables, etc.) or functional requirements (machining, inspection, etc.). Where cost savings estimates were based on vendor quotes or estimates, the general nature of the savings usually was described, but not in a quantitative breakdown. In cases where estimates were based strictly on existing, internally generated contractor information, it was verified that the same basic approach was used as described above in the initial paragraphs of this section.

Benefits other than manufacturing cost savings were identified to the extent possible, and were presented in the previous reports in the individual project narratives. Other than savings of critical materials or enhanced wartime surge capacity, most of these benefits relate to improvements in properties of the manufactured product. Examples are: lighter weight; improved fuel economy; improved reliability; increased life; and improved performance. The explicit objective of a number of contracts assessed was to establish a manufacturing process which would produce a higher quality, more mission-effective product, and not to reduce manufacturing costs. This fact should be kept in mind when reviewing the findings.

C. Project Limitations and Caveats

This project was not a comprehensive assessment of the Air Force MANTECH program. A program assessment would compare overall program costs with overall program payoff, over time. The 75 projects assessed in this program are only a fraction, and probably a small fraction, of all USAF MANTECH projects which have been or are now being performed. This project provides, however, a strong <u>indication</u> of overall program impact. The project-by-project and contractor-specific analyses provided a basis for identifying strategies for enhancing program benefits. The project's "bottom-up" approach helped provide an understanding of the underlying <u>reasons</u> for the program impacts which were found.

Since the methodology that was used in this program did not address the overall cost structure of components or systems, direct linkage between the identified MANTECH-generated savings and overall component or system production cost or selling price cannot be made. It can be said, however, that whatever the manufacturing costs currently (in 1982) are, they would be (or would soon be) higher by the amounts indicated in this study. The

For presentation purposes, all cost savings estimates are expressed in 1982 dollars. Conversion to 1982 dollars is based upon the Implicit Price Deflator for GNP.

The methodology required determining the differences in costs from utilizing the MANTECH supported technology to produce a given component, as compared to the best available alternative process. Professional judgement was used to pose and answer the necessary "what if" type questions for each case of implementation of a MANTECH-supported technology. The methodology did not require analysis of the overall cost structure of the components. Only cost differences were analyzed. Thus, the methodology is incapable of assessing or predicting overall manufacturing cost or selling price of the manufactured product.

Only readily identifiable and directly trackable and quantifiable benefits were assessed. Cost savings estimates were developed only for cases where implementation has already occurred or where implementation is programmed, that is, where production qualification is ongoing, proceeding satisfactorily, and the company is committed to implement if it proves out. Savings from potential future applications were discussed in the narrative but were not costed out.

Where possible, part-by-part savings estimates were developed and then used to compute savings per end item (engine, aircraft, missile, etc.). This was accomplished by multiplying the savings per part times the number of these parts per end item. The savings per end item, in 1982 dollars, was then multiplied by a forecasted production volume (including spares) from the first year after production implementation through 1992, under a peacetime scenario. Total savings from the process were estimated by summing the savings for all parts and all appropriate end items. Savings were computed starting in the first year after implementation to allow time for start-up problems and initial production inefficiencies to be resolved. There were a number of cases where implementation of a MANTECH-supported technology was extensive and the number of parts to be analyzed was extremely large. In these cases, a sample of parts was selected and analyzed.

Where a part-by-part analysis was not practical, a non-part-specific approach was developed which best applied to the situation. In these cases, savings were analyzed and reported on a work-station, flight-hour, factory-throughput, annual, or other such basis as appropriate.

The source for the forecast production volume varied across component and product lines. Contractor or USAF estimates were used where possible. The source for each estimate was presented in the individual project narratives in the earlier reports. It sometimes was necessary to report the findings in an aggregated form to prevent disclosure of proprietary sales forecast information. Savings were summarized according to USAF, military, and commercial produc areas.

In order to minimize the disruption and effort imposed on the MANTECH

We also found that the MANTECH emphasis on the need for contractors to implement these technologies if they were going to do a long-term business with the program, has had some effect. This "jawboning" certainly has been heard, for almost every manager and executive we talked with felt under considerable pressure from the MANTECH program to move the technologies they were working on into production. We believe this "jawboning" tends to motivate persons in contractor manufacturing engineering and manufacturing technology development organizations to work harder within their company for implementation--to contribute to the studies, the preparation of the paperwork, and all the other technical and bureaucratic activities required to implement new manufacturing technology.

In summary, it appears that long- and mid-term competitive pressure for maintaining state-of-the-art manufacturing technologies (and state-of-the-art efficiencies and costs) is the primary driving force behind implementation of MANTECH-supported technologies. Furthermore, these competitive forces appear to be highly effective at stimulating implementation. Air Force (especially MANTECH program) pressure also contributes to implementation. The most important additional step the Air Force could take to increase the implementation of MANTECH-supported technologies would be to provide a mechanism by which the contractor was assured of receiving a larger portion of the manufacturing cost savings that are generated. With the Tech Mod/IMIP program, this mechanism appears to be moving into place.

B. Impacts of Cost Accounting and Economic Analysis Procedures

The cost accounting and financial reporting systems used by contractors, and the economic analysis methodologies that are used, provide a bias for investments in processes and technologies that reduce direct manufacturing costs, at the expense of indirect manufacturing costs. Reductions in direct costs are immediately observable, trackable, and reportable. Indirect costs, on the other hand, are generally tracked plant-wide, and are allocated to output based upon their overall plant percentage of direct labor and material costs. Total indirects are typically more than 100% of direct manufacturing costs, yet the indirect costs are seldom analyzed directly in the economic analyses. Advanced, highly capital intensive, highly automated new manufacturing technologies tend to have an indirect cost structure vastly different from older technology equipment in place throughout the rest of the factory, which the indirect rate structure reflects. Allocating indirect costs to the new technology using a company's standard indirect loading factors, as is typically the case in the economic analyses that are performed, provides a very distorted view of a proposed project's overall economic attractiveness.

When contractors do take the effort to develop detailed estimates (predictions) of indirect costs from implementation, and it becomes known that they will be very high, it becomes very difficult to implement the technology or process. This is often the case even when there will be net savings overall. The problem in these cases is that by driving up manufacturing overhead and other indirect costs plantwide, the end items

produced in the rest of factory in effect will be "subsidizing" the new manufacturing system and the components produced with it. Therefore, even if the overall economics of the process are attractive, an implementation with expected high indirect costs will probably be hard to sell within the company.

To summarize, we find that implementation of MANTECH supported technologies is influenced by the cost accounting systems used by defense contractors. These accounting procedures date back to World War II, when direct costs represented the bulk of total part cost. Today direct costs typically are only a small fraction of total cost, yet they still drive cost accounting, product pricing, economic analyses, and the allocation of investment capital. Traditionally, factory manufacturing labor has been considered a direct cost and equipment an indirect cost because the man was the basic factor of production--the tool supported the man. With many advanced manufacturing technologies coming into use today, the man is there to support the tool. The entire cost structure of aerospace manufacturing is changing dramatically, yet without concomitant changes in cost accounting practices. The capability to conduct sound investment analyses, and thus to make good investment decisions, has seriously deteriorated.

C. Cost Targeting to Ensure Cost-Effective Manufacturing Technology

Eight MANTECH projects were found to have been technical successes but not sufficiently cost-effective to justify implementation. In the typical project we assessed, the technical work was accomplished, and at or near the end of the project an economic analysis was performed which compared the manufacturing costs of production hardware items using both the new and old (baseline) processes. Programs initiated since FY1981 contain requirements for a preliminary benefits assessment early on in the program, and a final benefits analysis at the conclusion of the program. We believe a cost targeting approach, discussed below, is superior to both methods.

Our recommended cost cost targeting approach consists of three main ingredients:

1) The establishment early in the MANTECH project of the cost baseline, which will provide the basis for developing cost targets which the new technology or process will have to beat. The cost targets should be based upon the best alternative state-of-the-art manufacturing approach. The cost targets will provide the basis for a prelminary benefits estimation.

2) The establishment early in the project of cost tracking and reporting procedures and responsibilities, for all cost and supporting data. This ensures that the appropriate data is generated and captured to be available when needed.

3) Continuing economic assessments and updates, and continuous feedback to the project manager, to provide ongoing knowledge of whether cost goals are being met, and to provide the basis for re-directing technical effort as necessary to meet cost targets.

Cost targets will provide both a focus and a boundary for project technical work. They will help define the realm of possible technical options, and determine where to concentrate project reources. At the completion of the technical effort, there will be no surprises regarding the economic attractiveness of the technology or process that was established. Most importantly, there will have been no lost opportunities for improving the cost-effectiveness of the technology.

There are two main challenges to the successful use of cost targets in MANTECH projects. The technology and cost baselines are dynamic--the costs of existing alternative processes are complex and constantly changing, and the processes themselves are changing. The cost target therefore may be a moving target. Another major challenge is not to let the cost goals stifle the creative process of innovation. Rather, cost targets should help guide and direct innovation.

Items #2 and #3 above are essential for the execution the cost targeting approach. The project manager will have the benefit of continuous feedback on how the cost of the new technology is comparing with the alternatives, so that rapid adjustments can be made in program technical work. The major cost factors and cost drivers should be identified early on and tracked to provide a focus for developing least-cost production technology. This will help ensure that at the end of the effort, when it is too late to do anything about it, the costs do not turn out to be too high.

Early planning and coordination is required for the collection and analysis of the cost and other information for cost targeting, cost tracking, and reporting. A data gathering and analysis plan for the economic analysis should be developed at the outset of the project. The plan should identify the cost and other information to be tracked, the specific individuals both at the contractor and any subcontractors who will be responsible for collecting the information, and the timeframe and format for collection and reporting to the economic analysis task leader and/or the project manager. Periodic mini-assessments of key cost drivers should be undertaken as conditions warrant, and integrated into periodic reviews of the technology's manufacturing cost.

It is important to realize that the nature of the economic analyses will change over the course of a project. In the early stages of a project, cost and payoff estimates by necessity will be somewhat soft, and in some cases, may have to be ordinal or generic. Over the course of the program the estimates will become increasingly detailed, and increasingly definitive. Each new round of cost analysis will build upon previously developed information. This is not to imply that all the uncertainty will have been removed from the economic estimates by the end of the project. Numerous simplifying assumptions may still have to be made, and considerable professional judgement applied. Some costs may have to be treated in an upper bound/lower bound aproach.

In summary, if cost savings are a major project goal, then it is important to conduct an aggressive economic analysis program. It will

require a rather substantial level of effort, and substantial changes from the way projects have been performed in the past. It will also require a change in attitude of the project staff. The key to success is to surface and resolve cost problems during the performance of the MANTECH project, not at the end when it is too late to do anything about them. The way to accomplish this is to develop and maintain a good understanding of costs throughout the project, and to know the cost goals that must be attained, so that work can be directed and re-directed to meet those goals. This approach requires full integration of the economic analysis function into the ongoing technical work. It requires a change in attitude of project managers and their technical staffs, to apply real thought to the economic analysis activity, to be receptive and responsive to its results, to avoid adversarial relationships with financial personnel, and to approach the entire economic analysis activity as a constructive endeavor as opposed to just another bureaucratic requirement.

D. Technology Transfer

Project resources allowed only a cursory look at technology transfer. An attempt was made to identify the transfer of technology across the eight firms for the specific technologies included in this program. Unfortunately, the results cannot be considered reliable. A major problem was identifying the proper sources of information in the companies and getting these organizations to expend the requisite time and effort, particularly when the technology or end item involved working with another company division. Another major problem that surfaced was a profound lack of inclination for technologists in these companies to admit to having brought in a new technology from a competitor. The pattern was for companies to explain their implementation of similar technologies as a result of their own internal efforts, although in many cases this was questionable.

One finding regarding technology transfer is that the project final reports are inadequate as the sole medium for technology transfer. All 75 project final reports were reviewed. Although there were some notable exceptions, the final reports tended to be overly positive in reporting project results and overly optimistic regarding the immediate technical and economic feasibility of the technology they addressed. From just reading the final reports, one would be hard pressed to identify any unsuccessful projects. When a project failed to establish the technology, the report tended to go into great detail describing the many smaller technical successes that were achieved, while glossing over the larger picture.

A short analysis was undertaken to determine the extent of dissemination of the project final reports through the offical channels of DTIC and NTIS. A large computer printout was obtained from DTIC which summarized all accessions through mid-1983. A sample was selected of ten limited distribution final reports for ten major technical and implementation successes. DTIC had no information on two of the ten projects (they were apparently lost). For the remaining eight, there were only 40 document requests from non-government sources. This averaged about one request per year per document. Also, an analysis of requests was

conducted for four final reports available through NTIS. The distribution of these was unlimited (reports are usually categorized initially as limited, and are sometimes re-categorized as unlimited later). For these four reports, there were 73 document requests overall, but over half of these were from foreign governments. Japanese, many European, and Soviet or Soviet bloc soures had obtained copies of all four unlimited distribution documents. Interestingly, the accession dates for the foreign governments tended to follow very closely the dates they were released for public distribution.

In conclusion, this brief analysis, while not conclusive, provides a rather strong indication that private industry in the U.S. does not extensively utilize DTIC or NTIS as sources of information for MANTECH projects or technologies. Secondly, it indicates that many foreign governments, including the Soviets, attempt to monitor the MANTECH program. One can presume that any program results released to the general public will almost immediately be picked up by the Soviets, and by Japanese and European competitors of U.S. corporations.

E. Letter of Intent

We recommend the USAF MANTECH program explore obtaining a "letter of intent" from its contractors, sometime before contract award. Such a letter would (morally, not legally) commit the contractor to implement the technology if it is technically successful and cost-effective. Realistically, we doubt whether "a letter of intent" alone would stimulate implementation, although it may help. The most direct payoff from such a strategy would be more realistic, more useful reporting of project results. There would be less of a tendency to call every project a success. Indeed, contractors would be accountable for explaining in detail why technically successful projects were not implemented.

F. Other Findings

There are several other findings regarding the Air Force MANTECH program that are worthy of mention. The program appears to steer company research and development resources into areas of direct interest to the Air Force. Also, it supports in-house manufacturing technology developers in pursuing higher risk and potentially higher payoff technologies. In general, we found the MANTECH program effectively supports organizations and individuals within these companies that are dedicated to advancing manufacturing technology. It enhances the stability of these organizations, which is very important for the successful and continual development and implementation of new manufacturing technology. Organizational stability is essential for the maintenance of technical teams and for providing continuity of development work. Undoubtedly, these internal organizations are highly effective advocates for the implementation of new and improved manufacturing technologies.

V. BENEFITS TRACKING STRATEGIES

A. Introduction

In conjunction with the analysis of implementation and benefits from the set of prior MANTECH projects, Applied Concepts Corporation also studied possible approaches for embedding a benefits tracking capability into the ongoing program. The objective was to develop a benefits tracking strategy which simultaneously: provides adequate data for MANTECH program management; meets the audit trail requirements of HQ/AFSC, DoD, and Congressional program monitors; is supportable by and acceptable to contractors; and is low cost.

B. Approach

The design of an optimal benefits tracking strategy required answering the following ten questions:

1. How should "benefit" be defined?
2. What should the methodology be for identifying, quantifying, and monetizing benefits?
3. How should benefits be allocated (both on the shop floor and to the MANTECH program)?
4. How should qualitative benefits be handled?
5. What should the timeframe be for tracking and reporting?
6. What should the reporting format be?
7. How should technology transfer be handled?
8. How should benefits tracking be organized and managed?
9. How much would such an activity cost?
10. What are possible mechanisms for requiring and financing benefits tracking by contractors?

Discussions on the benefits tracking issue were held with management and technical staff at each of the eight firms at which we worked. Contractor staff from manufacturing, manufacturing engineering, finance, and information systems organizations participated in the discussions. Each of the above ten questions were explored, as well as other issues and concerns raised by the contractors. The discussions were highly effective in providing an understanding of contractors' capabilities and preferences for tracking and reporting implementation and benefits of MANTECH-supported technologies.

Discussions were also held with HQ/AFSC and Air Staff personnel involved in the MANTECH program, to determine their requirements and preferences regarding benefits tracking. Two meetings were held with the GAO staff who are responsible for evaluating the Air Force MANTECH program to determine their requirements for identification of program benefits.

Discussions were also held with Army and Navy MANTECH program offices responsible for implementation and benefits tracking activities. NASA's technology transfer and benefits tracking organization was also visited.

The project team studied in detail how these organizations track the implementation and resulting benefits of their programs. We explored the implications of the different approaches, and their lessons learned in establishing and managing a benefits tracking capability. A number of other organizations were contacted—including the Aerospace Industries Association, the Defense Technical Information Center, and the Center for the Utilization of Federal Technology--to learn about possible approaches to benefits tracking and to identify technology information sources.

We also assessed, to the extent possible, the current benefits reporting procedures that were established by the MANTECH division in FY1981. These procedures require MANTECH contractors to establish plans for technology transfer, implementation, and benefits tracking. The requirements were included in new contracts beginning in late FY81. No MANTECH project had progressed to the point of compliance with the requirements during the performance of this benefits analysis project. Although there was no performance base for assessment, the discussions with the contractors addressed this subject. At the time of our meetings, many of the contractors were in the process of determining how to comply with the requirements.

It was anticipated at the initiation of this task that the most effective research approach would be to develop five alternative benefits tracking scenarios, as the basic unit of study, which could then be comparatively evaluated. As a result of experience gained during the data collection (interview) phase, it was found that the ten benefits tracking elements, identified at the beginning of this section, were a more productive scheme of organization. In other words, they were the natural variables of the analysis.

The evaluation segment of this task was therefore carried out among alternatives to each of the ten elements of benefits tracking. The preferred scenario was then constructed from the superior alternatives for each of the ten variables.

C. Findings

This section presents the findings for the Benefits Tracking Strategies task. Findings are presented separately for each of the ten key questions mentioned above. These ten questions reflect the ten key elements of any benefits tracking strategy.

1. How should "benefit" be defined?

It is clear that the definition of "benefit" preferred by contractors, at least for dollar benefits, is the manufacturing cost savings that can be

directly attributed to the implementation of the technology or process. This would include all fully burdened direct and indirect manufacturing cost savings, but would not include corporate or divisional G&A, IR&D, or profit loadings. The reason for this preference is that this is the type of data that is customarily used by and readily available to the manufacturing engineers and financial staff who will perform the benefits analyses.

The research team believes that due to the general lack of solid information on indirect costs, and the difficulties in allocating indirect costs to specific processes and pieces of equipment on the shop floor, there will be a tendency to focus on savings in direct costs, and to understate indirect cost impacts, both positive and negative. This is an inevitable result of the cost accounting practices in use today in the defense aerospace sector, as discussed in Chapter IV. Contractors should be encouraged to take special efforts to identify the impacts of implementaton on indirect costs. This will typically require special studies, and the use of professional judgement to allocate indirect costs.

There may be economic benefits from other than savings in manufacturing costs. Many MANTECH technologies result in technical improvements to the manufactured product that yield lower costs later on. These include such savings as reduced fuel consumption from the use of lighter weight components, reduced maintenance requirements from a more durable product, etc. These economic savings can be estimated by contractor staff utilizing performance data on the components or end items, which they usually have in their possession, or can obtain. Estimating the impact of qualitative improvements on fuel savings, maintenance, repair and other life cycle costs will require professional judgement, but it can be done. The key here is to document the assumptions behind the estimates.

In contrast to manufacturers, Headquarters AFSC and GAO would like to know the actual savings to the government from implementation of these technologies. This requires knowledge of the impact of manufacturing cost savings on product prices. This is a complex task, requiring extremely detailed analysis of the total cost structure of each componenet impacted, and a detailed study of the procurement contracts through which each item is acquired over time. Even with a great expenditure of effort, so many assumptions and allocations would be required that the resulting figures still would be very soft. Any effort to estimate impacts on prices would require major participation of contractors' contracts and pricing personnel, and would have to go through a high level corporate review process. It would also have to be coordinated with the Air Force system manager and procurement office. In summary, assessing the end-item price impacts of specific new processes for specific components would be a very high cost undertaking, and would not be well-received by the contractors.

The definition of "benefits" to be used should be consistent with the objectives of the benefits tracking program. Benefits assessment is the feedback loop that allows MANTECH program management to continuously monitor and adjust the program, as needed, to maintain and enhance program

effectiveness. The questions that program management needs answered are:

1. Are the projects leading to technically attractive manufacturing processes and technologies? Why or why not?

2. Are the technically successful projects being implemented? Why or why not?

3. Are the implemented technologies yielding manufacturing and other cost savings, or other benefits, that will be passed on to the Air Force? Why or why not?

4. What can be done to enhance the program's success rate--regarding technical success, implementation, and benefits generation?

We recommend defining "benefits" as the manufacturing cost savings and life cycle cost savings resulting from implementation of MANTECH technology. This is essentially the definition used in the benefits analysis of the 75 past projects. We recommend not attempting to link manufacturing cost savings and other benefits to end-item prices. Such a requirement would be highly disruptive to the program, and could have serious, negative impacts on the MANTECH program's working relationship with contractors. It would be very expensive to implement, and would tend to inhibit contractor participation in the program.

Acceptance of the recommended definition implies that the connection between system cost and price be made external to the MANTECH program. This is currently the case. As described in the methodology chapter (Chapter II), the procurement policies of the Air Force and Federal government make it highly likely that most or all of the manufacturing cost savings are ultimately passed on to the government.

We believe the most important information to track on a continuing basis is that on technical results and implementation. It is essential for the MANTECH program to know continuously the state of these technologies, that is, their degree of readiness for the shop floor. Based upon our review of 75 technical reports, project briefings, numerous films, and discussions with contractor and MANTECH engineers, we believe that, at any particular time, the technologies tend to be portrayed by contractors as somewhat more technically ready than they in fact are. A benefits tracking strategy must provide for an accurate tracking of projects' technical status, in the context of the overall state of the technology.

Tracking implementation is also key to program monitoring and benefits tracking. If technologies are being implemented, it can be safely assumed that real benefits are being generated--cost, technical, or both. What is important is to track the implementation status of the technologies. In tracking implementation, it is important to distinguish possible future implementation from actual, ongoing, or definitely programmed implementation. Contractor personnel may say they plan to implement a technology, but the plan may only be in the minds of one or several

individuals.

2. What should the methodology be for identifying, quantifying, and monetizing benefits?

It is clear that the identification of implementation and resulting benefits must be performed, at least partly, by the contractors. They have possession of the requisite information on plant and process-specific costs. They can best apply the engineering judgement necessary to develop new data that may be required. Since linkage with component or end-item prices will not be attempted, an analysis is not required of the overall cost structure of components manufactured by the new process. What is required is a determination of the manufacturing cost differences from using the MANTECH technology as opposed to the best available alternative technology. The life cycle cost impacts, and technical, performance, and other benefits attributable to the new method of manufacture must be identified. This approach was successfully used in the benefits analysis of 75 past projects. It is acceptable to the contractors. It is relatively low cost, because it requires addressing only those factors impacted by the new technology.

The recommended benefits assessment methodology entails determining the differences in costs from utilizing the MANTECH technology to produce a given component, as compared to the best available alternative process. The best alternative may not be the baseline or "as is" process. In order to be implemented, the MANTECH technology typically must out-compete one or several other manufacturing approaches, all of which may be an improvement over the baseline or "as is" process. Professional judgement must be used to pose and answer "what if" questions for each case of implementation, in order to develop the requisite data.

The appropriate method for calculating savings will be technology and process dependent. Where possible, savings per part should be developed and then aggregated to end-items. Where a part-by-part analysis is not possible, a non-part-specific approach will need to be developed that best applies to the situation. Such cases, typically, will result in savings being reported on a work station, flight hour, factory throughput, annual, or other such basis. The savings per end item or per other basis should then be extrapolated over the projected production base.

When manufacturing cost savings and other economic benefits are estimated, it is important to control for, and to specify the year of the dollars reported. It is not necessary to have all the cost analyses performed in the same year dollars, because findings expressed in any year dollars can be translated into any other year dollars by using conversion factors. For making such conversions, we suggest the implicit price deflator for GNP, since it is the broadest measure of the change in the (domestic) worth of a dollar from year to year.

If the cost of benefits tracking is to be minimized, it is essential

to make maximum use of existing information. Value engineering studies are usually performed before a new process is installed, and other special cost studies may be performed from time to time on the process in question, for contractor purposes or to satisfy government requirements.

A key question is whether the benefits estimates should be based upon up front estimates or validated post-implementation cost studies. The recommended approach is to use projections until hard data can be obtained. Post-implementation cost analysis is essential. In the analyses of 75 past projects, large differences often were found between the projected savings in the final report and the actual savings determined from operational experience.

Since post-implementation studies are not customarily performed, such a requirement will have to be imposed upon the contractor by the MANTECH Division. Costs can be minimized by making this an analysis to verify the estimates made before production was underway. Only those cost factors affected by the new technology need to be assessed.

3. <u>How should benefits be allocated (both on the shop floor and to the MANTECH program)?</u>

Factoring out the cost impacts of a specific process or technology within complex and dynamic aerospace manufacturing operations is very difficult. It requires the exercise of considerable professional judgement of personnel familiar with the process under analysis, and how it integrates into other tasks, and costs.

Identifying the specific impacts of the MANTECH technology is difficult because of the number of variables involved and the complex relationships among them. In addition to the new MANTECH process, most other aspects of manufacturing are changing--part design; materials; prices of labor and material; production quantities; and downstream and upstream processes into which the MANTECH process must be integrated. Because of the complexity, the process of cost allocation on the shop floor must be made by the exercise of professional judgement utilizing all available technical and cost information.

Whether or not, or to what extent, the MANTECH program deserves credit for the establishment and implementation of a technology is also an allocation decision. The benefits analysis of 75 past projects originally attempted to allocate benefits from implementation according to MANTECH's contribution to the establishment of the technology. MANTECH was to be allocated from 0%-100% of the benefits identified from an implementation. The percentge was to be based upon a judgement call to be made after having discussed the history of the technology and the MANTECH contribution with contractor and MANTECH staff.

This approach was dropped because it was found to be unworkable. Opinions of individuals differed greatly, and little or no hard evidence was available on which to base the allocations. The fallback position,

which was adopted for the benefits analysis of past projects, and which is recommended for continued benefits tracking, is an "all or nothing" allocation. The criterion should be whether or not the MANTECH program played an important role in establishing the technology as production ready. If it did, all benefits should be attributed to MANTECH. If it did not, the MANTECH program should not be attributed any benefits.

4. <u>How should qualitative benefits be handled?</u>

Qualitative improvements can yield lower life cycle costs, or improved technical performance. Estimated impacts on life cycle costs can and should be quantified and monetized. We know of cases where a MANTECH process increased manufacturing costs, and it was known that the part prices to the Air Force increased, but this was acceptable due to reduced maintenance and other life cycle costs, and reduced aircraft downtime. Qualitative impacts should always be described and explained in a narrative.

5. <u>What should the timeframe be for tracking and reporting?</u>

The benefits analysis of 75 past projects extrapolated benefits over an approximate ten year period. We believe a ten year period is consistent with the longevity of these technologies on the shop floor, and the length of end-item production runs. There is no reason, however, why the savings should not or could not be projected over the entire estimated production volume of the end-items affected, whatever the time period might be.

GAO, with its auditing persepctive, stated a desire to know actual, historical benefits. Given the usual amount of time required for performance of MANTECH projects and for implementation, analysis would be conducted in say, 1984, to assess the benefits of 1964-1969 MANTECH projects. This leads to the two main problems in using an historical, auditing approach. First, the findings are ten to fifteen years out of date by the time the analysis is finished. Such an assessment would not provide the MANTECH program or Congress with an accurate picture of how the MANTECH program is currently performing, or provide information on how to improve current operations. This is important, because the MANTECH program is constantly changing, in terms of both technical and management aspects.

Secondly, assessing projects performed fifteen or twenty years ago will be difficult due to the fact that many or most of the personnel involved in the projects will no longer be at the contractor, and many of the records and other data will be lost or destroyed. This is crucial in an analytical methodology that relies so heavily on professional judgement. Our assessment of five to ten year old projects suffered from this problem. It is doubtful that fifteen or twenty year old projects can be reliably assessed. Even a weak assessment will be at a very high cost, since more effort will be required to find and develop data.

Both methods--analyzing current findings and extrapolating savings into the future, and analyzing past savings based upon historical data--result in some imprecision of results. Given the need to provide as rapid a feedback loop as possible to MANTECH management, there can be little doubt that a forward extrapolating methodology is the preferred approach.

The timeframe for reporting benefits is somewhat arbitrary. An annual comprehensive reporting of implementation status and benefits, realized and projected, is an attractive, but expensive, approach. Contractors appear willing to report implementation status annually. In fact, they would prefer such an accounting once a year, with a known delivery date, to what they now perceive to be an ad hoc process of frequent questioning and reporting, often on very short notice. Reporting of implementation status might be every year, with determination and reporting of estimated benefits beginning once an implementation decision has been made, or periodically, perhaps every two or three years.

6. What should the reporting format be?

The first decision in answering this question is whether or not to require a standard reporting format. A standard format is attractive to the Air Force and GAO because it allows aggregations to be readily made, promotes comparability of results, and is quick and easy to read. The drawback to standardized reporting is that it requires contractors to force their data into categories which may not be relevant. Breakdowns may have to be made arbitrarily or based upon rough estimates, and meaningful information may be lost. The conversion from contractor to Air Force categories will result in distortion of the findings.

We believe it not is desirable to use a standardized or highly structured reporting format. However, the reporting of bottom line benefits should be consistent across all contractors. The methodology provides for this. Manufacturing cost savings and life cycle cost savings will be determined and reported on a part-by-part basis, where possible, and aggregated to end items. Even where savings cannot be determined on a per part basis, it will often be possible to aggregate savings to end items. Non-economic technical and performance benefits will be described in narrative form.

The basis for the benefits estimates, for both economic and non-economic benefits, should be clearly presented. The nature of the savings, and of the information used to identify savings, are likely to vary greatly across implementations, even at a single contractor. There is little to be gained, and much to be lost, from standardizing the reporting of such back-up information. We do not recommend forcing the contractor to use the cost categories in the current requirements.

What is important is to document the legitimacy of the benefits estimates that are provided. This can be done through a narrative

explanation of the costs that are affected, how the benefits were calculated, the assumptions that had to be made, and how per unit savings were extrapolated to the production base. Since contractors' cost information systems do not track costs by specific processes, engineering cost estimates will have to be developed. Contractors need flexibility in order to exploit available information (and thus keep costs down), and to tailor the analysis to the particular circumstances of the application.

The narrative discussion will present and explain the nature and magnitude of the cost savings, either in terms of manufacturing inputs (labor, material, consumables, etc.) or functional requirements (machining, inspection, etc.). Vendor quotes may be used for out-sourced components. The narrative will report on the analytic approach used and the results. Forcing the analysis and presentation of results into pre-set categories such as are now required will result in a less accurate understanding of the economic impact of the technology.

7. How should technology transfer be handled?

Probably the most important finding in this area is that a contractor cannot be expected to track technology transfer beyond its own firm. Contractors should be expected to track technology transfer across different corporate divisions.

It appears to us that the most cost-effective locus of technology transfer tracking would be the MANTECH engineer, or the MANTECH branch office. MANTECH staff are in continuous contact with the entire body of contractors, and it appears to be within the existing scope of their job to keep abreast of the implementation status of advanced manufacturing technologies.

The goal of technology transfer tracking is to help ensure that attractive technologies get picked up and implemented by other aerospace firms, to the benefit of the Air Force. Therefore, once a technology has "taken off" and is rapidly spreading throughout the industry, there is little additional managerial benefit to be gained from continued tracking of the transfer of this technology.

8. How should benefits tracking be organized and managed?

There are three key decisions that must be made regarding the organization and management of a benefits tracking program:

1. The periodicity of benefits assessment and reporting—once a year or periodically, every other year, every three years, etc.
2. The degree of required coverage—100%, a sample of projects or technologies as in the benefits analysis of past projects, etc.
3. The level of MANTECH staff participation—performed 100% in-house, partly or wholly contracted, etc.

Pratt & Whitney Aircraft

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
AIRCRAFT EQUIPMENT DIVISION							
High Information Rate Cockpit Display	1.754	1978	1982	T E C H N I C A L		B E N E F I T S	
MNOS Memory Arrays	.255	1976	-	-	-	-	-
G.E. SUBTOTAL	7.476	For Implemented, Avg. Time To Impl = 2.6 Yrs		46.1	74.0	252.6	$326.6

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
GENERAL ELECTRIC COMPANY

Savings are in 1982\$, from Implementation Yr + 1 through 1992, in \$1,000,000s
Project costs are in nominal dollars, in \$1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
AIRCRAFT, ENGINE BUSINESS GROUP							
FL ION/ADH Vane Repair	.268	1979	1981-1982	-	-	195.8	195.8
Process For High Integrity Castings	.299	1974	1975-1976	14.8	24.0	32.6	56.6
Laser Drilling/Adaptive Controlled Laser Drilling (2 Projects)	.633	1975	1978	10.3	23.6	22.5	46.1
NNS Processes for ODS Vanes	.497	1979	1983	20.3	25.7	-	25.7
NNS Desk Inspection System	.398	1979	1982	.7	.7	1.7	2.4
Automation of Thermal Spray Process	.450	1979	1983	T E C H N I C A L		B E N E F I T S	
Large Superalloy Castins Using Segmented Molds	1.229	1979	-	-	-	-	-
HIP of Ti Powder Alloy Preforms	.286	1974	-	-	-	-	-
Pressure Bonding of Shrouded Blades and Vanes	.491	1979	-	-	-	-	-
RE-ENTRY AND ENVIRONMENTAL SYSTEMS DIVISION							
C-C Composites for RV Nosetips (2 Projects)	.916	1977	1977-1978	T E C H N I C A L		B E N E F I T S	

G.E. MANTECH Projects - Summary of Implementation & Benefits

	Status of the Technology	Year of Initial Implementation	Estimated G.E. Savings Through 1992 (in 1983$)
[illegible] VANE	Now implemented at G.E. repair facilities worldwide. Licensed to Motorturbine Union (Germany) and exploring licensing with other firms. Also major spin-offs to other repair processes (these savings are not included).	1981-82	$195,800,000
[illegible] HIGH [illegible] CASTINGS	137 different G.E. parts produced by this process. Savings estimates are based on sample of ten parts. Extensive use of this process in aerospace industry.	1975	$ 56,536,000
[illegible]LLING & CONTROLLED [illegible]LLING [illegible]s)	Used to drill holes in 13 different parts in 6 engines. Is now the hole drilling method of first choice for turbine airfoils. 15 laser drill machines installed with more on order. Becoming increasingly cost-effective and utilized in aerospace industry.	1978	$ 46,144,000
[illegible]SES [illegible]ANES	Implementation programmed for 4 parts in 3 different engines.	1983	$ 25,707,000
INSPECTION	3 machines installed at G.E. to inspect disks, seals, blade retainers, spools, and engine mounts. Expanded utilization likely in future. Also implemented at other engine companies and vendors. Enhances prospects for NNS and NS production processes (these savings are not included).	1982	$ 2,448,000
[illegible]N OF [illegible]SPRAY	One system currently being installed at Cincinnati Flame Spray (a G.E. subsidiary); 2 more systems in process of installation and qualification at G.E. plants in Schenectady, N.Y. and Albuquerque, NM.	1983	Main benefit is technical but some cost savings expected. Insufficient operating experience to assess savings.
[illegible]ERALLOY [illegible]USING [illegible] MOLDS	Technical success but not implemented. Eclipsed by advances in large integral casting (also supported by MANTECH).	—	—
[illegible]LOY	Technical problems—severe powder contamination. No implementation. MANTECH has ongoing program to develop clean powder. A number of other ongoing MANTECH efforts are exploring use of this technology for other applications (engine mounts, compressor impellers). Advances in competing technologies (cast + HIP, isothermal forging, etc.-- also supported by MANTECH) have lessened the need for powder Ti technology.	—	—
BONDING OF BLADES &	Proven technically feasible for some applications, but cost savings insufficient to implement. G.E. now investigating use in blisk production and repair, through Navy MANTECH.	--	—
[illegible] [illegible]S FOR RV (2 Projects)	Implemented at G.E. for RV nosetips and rocket nozzles. 1400 nosetip billets produced to date, with 500 more on order. Used on Minuteman III and MX RVs. Over 100 rocket nozzle billets produced to date.	1977 (nosetips) 1978 (rocket nozzles)	Benefit is technical--a more accurate RV. Laid preliminary groundwork for batch processing which has led to cost savings of $10,000+ per nosetip billet.
[illegible]RMATION [illegible]PIT DISPLAY	Implemented in PAVETACK System in 79 F111F aircraft. G.E. under contract to implement in Australian Air Force F111Cs. Not implemented in F-4, F-16 or B-1, but potential future applications.	1982	Benefits are mainly technical 25% improvement in bombing accuracy and 4:1 avg. force improvement (fewer required sorties, lower aircraft attrition, etc.)
[illegible]Y ARRAYS	Project was a partial technical success but the technology has been eclipsed.	—	—

TOTAL ESTIMATED SAVINGS THROUGH 1992 = $326,735,000

General Electric Company

APPENDIX A

SUMMARY FINDINGS FOR INDIVIDUAL CONTRACTORS

Benefits tracking program staff will have access to and control over the appropriate portions of the computerized MIS. They will have authority to task MANTECH engineers for specific data or assistance, as needed. MANTECH engineers will be authorized to task the benefits tracking program for information on technology implementation and benefits, and for other data it maintains, as needed.

9. <u>How much will benefits tracking cost?</u>

A fully adequate (high cost/high effectiveness) benefits tracking and reporting program would cost $400,000-$500,000 in the first year, with subsequent annual costs of approximately $300,000, in 1984 dollars. A low cost but still moderately effective program could be performed for $100,000 per year, with no extra initial start up cost.

10. <u>What are possible mechanisms for requiring and financing benefits tracking by contractors?</u>

The cost targeting approach, presented in Chapter IV, should be implemented through the MANTECH contrat. This will ensure a sensitivity to costs from the outset, and will help ensure that adequate cost tracking data is available when the technology is implemented.

The recommended benefits tracking approach imposes a low enough level of effort upon the contractors that they can be expected to perform their portion of the work on indirect funds. No new contractual mechanism is required.

The incentive for contractor participation in the benefits tracking effort will be potential future work for the Air Force MANTECH program.

7. <u>How should technology transfer be handled?</u>

Along with the information on implementation status, MANTECH contractors should identify other organizations within the company that are using or planning to use the technology. Information on the types and amounts of benefits from these applications should be provided, if possible. Other known or potential users of the MANTECH technology outside the company should also be identified.

Each year, the benefits tracking program office (to be established) should circulate a list of MANTECH technologies to all MANTECH contractors to detrmine the implementation status of the technologies across the industry. An attached questionnaire would ask the contractor to identify those MANTECH technologies it has implemented or which it plans to implement. The technologies list should be updated each year. The responses by contractors should be input into a computerized data base on technology implementation and/or technology transfer. It should be noted that follow-up work will be required for this mail-out implementation/technology transfer questionnaire, to verify that the technologies which were stated as implemented were those specifically addressed by the MANTECH program.

8. <u>How should benefits tracking be organized and managed?</u>

A benefits tracking program office should be established within the office of the Division Director. This office will direct all MANTECH benefits tracking and reporting activities. It will maintain the implementation, benefits, and technology transfer portions of MANTECH's management information system (to be established). The benefits tracking work can be performed by dedicated staff, a contractor, or a combination of both. The decision on the level of contractor support can be made based on staff availability criteria.

The recommended timeframe for performance of benefits tracking is annual reporting of implementation status, with periodic detailed benefits assessments of contractors, in rotation. There should be an ongoing contractor assessment effort, and each participating contractor should be assessed at least once every three or four years.

Approximately twenty projects, emcompassing four or five contractors, should be assessed in detail each year. This will be a partial assessment in the near-term (due to a backlog of unassessed projects) but over time will represent a larger percentage coverage, because the number of MANTECH projects has been decreasing. As much as possible of the work should be performed by the benefits tracking program team. The imposition of work upon the MANTECH contractor can and should be kept to a low enough level such that their efforts can be funded through indirect accounts.

inspection, etc.). Where savings are based upon vendor quotes or estimates, whatever information can be readily obtained from the vendor(s) on the nature of the savings should be reported.

3. How should benefits be allocated (both on the shop floor and to the MANTECH program)?

Benefits should be attributed to the MANTECH program in an "all or nothing" manner. If MANTECH played an important role in establishing the technology as production ready, the benefits resulting from implementation should be attributed to it. If MANTECH's role was minor or peripheral, it should be attributed no benefits from the implementation. The determination of MANTECH's role in the implementation should be made by the implementing contractor.

The estimation of cost savings attributable to a specific MANTECH process can be a very complex undertaking. It often requires the exercise of considerable professional judgement to identify the manufacturing costs of a specific process and to allocate them to the specific parts of that process impacted by MANTECH. Other changes are taking place on the shop floor, in addition to the new MANTECH process. Cost impacts of MANTECH often must be factored out of complex, interrelated changes in part design, materials used, downstream and upstream processes, unit prices of labor and materials, production quantities, and other factors. It should be documented how professional judgement was applied to factor out the impact of MANTECH from all the other changes impacting the manufacturing process and its costs.

4. How should qualitative benefits be handled?

Qualitative benefits should be described and explained in narrative form. Also, they should be quantified and monetized wherever possible, and the estimation procedure and assumptions documented.

5. What should the timeframe be for tracking and reporting?

Implementation status should be reported every year by every MANTECH contractor for every technology area in which they have been involved. A benefits analysis should be performed at every contractor no less than every three years, focusing on projects that have been completed during the last three years, and updating the status of those completed before that (and which already will have been reviewed in a previous assessment). When an implementation is initially reported, an estimate of expected benefits also should be submitted.

6. What should the reporting format be?

A standardized or structured format is not recommended. The methodology and reporting requirements, presented above, provide for comparability of results, and provide the capability to aggregate results across contractors.

to sum the savings for all impacted parts to determine savings for the end item. Total savings per end item should be calculated by multiplying the savings per end item times its estimated production quantity over a ten year period. Total overall savings for the MANTECH technology at a contractor should be estimated by summing the total savings for each end item.

The source for the estimated ten year production volume should be given. It may be necessary in some cases, particularly in commercial product areas, to report findings in aggregated form to prevent disclosure of proprietary sales forecasts of individual end items.

Manufacturing cost and life cycle cost benefits should be determined for each impacted end item, where possible. Where savings cannot be attributed to a particular end item, they should be expressed in average annual savings, for a ten year period. The year of all dollar figures that are presented should be specified. Technical or qualitative improvements to components or end items, and their resulting mission benefits, should be described in narrative form. The basis for the estimates of technical and mission benefits should also be presented. Linkage of savings and other benefits to end-item prices should not be attempted. Total savings should be broken down into USAF, military, and commercial subtotals.

Where a part-by-part analysis is not practical, a non-part-specific approach should be used that best applies to the situation at hand. In these cases, savings might be analyzed and reported on a work station, flight-hour, annual, or other such basis.

Savings estimates should only be developed for those cases where implementation has already occurred or where implementation is programmed, that is, where production qualification is ongoing, proceeding satisfactorily, and the company is committed to implement if it proves out. The likelihood of future implementation, and its potential benefits, should be discussed in narrative form, but not costed out.

Maximum practical use should be made of existing information. No, or very little, new data on costs or manufacturing operations, or new technical data, should be generated. Value engineering studies, ongoing contractor cost and operations analyses, vendor quotes, DCAA and AFPRO data, and other such sources should be fully exploited. Professional engineering judgement, coupled with expert knowledge of the manufacturing cost structure of the plant, and building upon available data, should be adequate to develop reasonably accurate estimates of manufacturing cost savings and other benefits.

Making maximum use of existing data usually means using it in whatever form it was generated. Therefore, a standard reporting format for reporting the impacts on individual cost elements should not be required. However, for each application, the nature of the cost savings should be reported, either in terms of manufacturing inputs (labor, material, consumables, etc.) or functional requirements (machining, finishing,

available for the benefits assessment. The challenge is to find a way to require and to fund contractors to track implementation and benefits after the MANTECH project has been completed. Imbedding a contractual requirement for continued work after a MANTECH project is closed out is not allowed by regulation, according to the ASD procurement personnel with whom we discussed this issue. For USAF negotiated contracts, contractors cannot be paid in advance for work to be performed beyond the contract period, under either cost-plus or fixed-price procurement. Furthermore, current procurement practices limit negotiated contracts to a five year period, and the Air Force, and the contractors, desire to close out their MANTECH contracts as soon as the deliverables are made.

A separate contractual document, and probably another procurement request document, would be required for the MANGECH program to directly fund tracking of implementation and benefits by contractors. Contractors now must fund post contract benefits analysis efforts through G&A or other indirect accounts.

Any effective benefits tracking strategy will require work of contractor personnel. However, a periodic, retroactive "snapshot" benefits tracking strategy will require substantially less work by contractors than continuous tracking with 100% project coverage. With the "snapshot" approach, funding by indirect accounts is feasible.

D. Recommendations

This assessment has led to the formulation of a recommended benefits tracking approach for the MANTECH Division. The recommended approach is presented below.

1. How should "benefit" be defined?

"Benefit" should be defined as manufacturing cost savings, and life cycle cost savings, attributable to the implementation of MANTECH technology. It also should include the qualitative improvements in components and end items that result from the use of a MANTECH manufacturing process or technology. Cost savings benefits should include all fully burdened manufacturing cost savings, and maintenance, repair, and other life cycle cost savings. Dollar savings figures should not include corporate or divisional G&A, IR&D, or profit loadings.

2. What should the methodology be for identifying, quantifying, and monetizing benefits?

The manufacturing cost and life cycle cost differences from using the MANTECH technology, as opposed to the best available alternative technology, should be estimated. Professional judgement should be used to pose and answer the necessary "what if" type questions, using the contractor's best available manufacturing cost and operations data. Where posible, savings should be estimated on a per part and per end item basis. Where more than one part in an end item is impacted, it will be necessary

have gone up to some extent. With at least five contracts to be assessed at each company division, and with the same approximate percentage of implemented projects as in the previous effort, we believe retroactive, "snapshot" benefits tracking could be accomplished for $3,000-$5,000 per assessed project.

It will not be possible to assess multiple projects at limited numbers of contractors if the assessment is to be current. Several years will usually be required to accumulate five (closed out) projects at an individual contractor.

A tracking strategy that would provide more current feedback would have to perform a broader assessment, of more projects at more contractors. One option would be to assess, each year, all projects which had been closed out two, or perhaps three, years before. This would allow time for implementation to have occurred and empirical data on manufacturing costs to be in place. Without the grouping by contractor, the assessment cost per project could be expected to be $5,000-$8,000.

With 15-20 projects coming up for detailed benefits assessment each year, at least until 1988 or beyond, a benefits analysis of all past projects, as described above, could cost between $45,000-$160,00 per year. We believe a highly effective program could be performed for $100,000 per year.

A continuous, more detailed benefits tracking effort would cost substantially more. Approximately two person years of effort per year would be required to track all projects, maintain the benefits assessment portion of the information system, and prepare periodic reports. There would also be a rather high one-time cost to establish the benefts tracking portion of the MIS, to catch up with the backlog of completed but unassessed projects, and to load the data base. We estimate first year cost to be $400,000-$500,000, and approximately $300,000 per year after this. Both figures include substantial travel costs for on-site work at contractors, and a major information management and reporting effort.

Our experience across a wide range of Federal programs is that it is not uncommon to expend 1%-2% of program funds for evaluation. At approximately $60,000,000 per year in program funding, such percentages would yield $600,000-$1,200,000 for program evaluation. Our high cost/high effectivensss evaluation program would require only about one-half of one percent of MANTECH program funds. The cheaper approach (retroactive, "snapshot" assessment) would require less than two-tenths of a percent of all program funds.

10. <u>What are possible mechanisms for requiring and financing benefits tracking by contractors?</u>

A cost targeting approach, as presented in Chapter IV, can be implemented within the project statement of work and funded by regular project resources. This will lay the groundwork for having good data

learn to use, are not particularly user friendly, and make it very difficult to control the quality of input data. We suggest developing a custom-made, minicomputer- or microcomputer-based management information system under direct control of the MANTECH program, or its contractor, which would incorporate a benefits tracking capability as part of a broader program management and technology information system.

Ideally, the benefits tracking system would be an extension of a broader project tracking and management system. Under a 100% sample approach to benefits tracking, no MANTECH project would ever leave the project tracking and management system. The history of what happened after project completion would be added to the information on the project and its performance. A file on each project would be maintained indefinately, or until a follow-on project began at the same contractor in the same technology area. The previous project would reference the follow-on project for the continuation of its history.

Lastly, there is the option of performing periodic "snapshot" benefits assessments, such as performed in the benefits analysis of 75 past projects. This is probably the lowest cost approach. We believe it is a perfectly adequate approach for validating the impact of the program to outside program monitors. However, it is less effective in providing feedback to MANTECH program management on how the program is operating. There is a longer time lag in developing and reporting the information on implementation status and benefits, and therefore the findings are more out of date than under continuous annual tracking and reporting. Also, the "snapshot" approach can and probably should be based on a representative sample of projects, but this will not yield a thorough report on every project, contractor, and technology.

9. <u>How much will benefits tracking cost?</u>

The benefits analysis of 75 past projects cost approximately $3000 per assessed contract. This low cost is due largely to the fact that numerous projects were assessed at each individual contractor, and many of the big winners, which required a great deal of analysis, were concentrated within two companies. There is a large additional fixed cost of working with each additional contractor. There is also an additional fixed cost of working with each additional division within a contractor. Once one project has been assessed, the marginal cost of assessing one or several other projects at the same company and division are not great. For this reason, a retroactive "snapshot" benefits tracking strategy of lowest cost would attempt to limit the number of different contractors, and different company divisions, involved in each round of assessment.

The performance of a benefits assessment of past projects today could be performed more efficiently than in this initial effort. The methodology is now established, and we have become proficient in applying it. Good contacts and working relationships have been established at many of the contractors that will be included in future assessments. However, travel costs have increased substantially in the past two years, and all costs

Clearly, the more often and the more comprehensive the benefits assessment, the more reliable is the information that is developed. On the other hand, a continuous, detailed benefits assessment effort will be very expensive. NASA spends tens of millions of dollars every year in a continuous, comprehensive program to track implementation and benefits of the technologies it helps develop.

The decision on the appropriate management and organizational structure of a benefits tracking program must consider the costs, as well as the availability of MANTECH Division personnel to perform the work. The higher cost of higher levels of effort must be weighed against the resulting improvements in the accuracy and reliability of results, and the need for such improved accuracy and reliability. The analysis that was undertaken in this program can provide guidance on the costs and implications of various approaches, and on how to maximize the effectiveness of any benefits tracking strategy. Where to actually make the cost/quality tradeoff for the benefits tracking effort is a MANTECH program management decision, which must be made in the context of overall program priorities.

We believe the benefits tracking function should be separated from regular, ongoing MANTECH technical activities, in order to focus responsibility for its accomplishment. Benefits assessment should be a staff function, and should be placed within the Division Director's office. This will ensure it is perceived by contractor and MANTECH personnel as having a high level of authority.

MANTECH engineers already have major responsibilities and heavy workloads in planning and managing projects. It is not realistic to expect them to take on the additional responsibility of benefits tracking. Also, when responsibility for a job is dispersed across a large number of personnel, there is a high probability that it will not get done. The engineers and branch managers will need to provide input to a benefits tracking function, and benefits tracking staff will need to be able to task them to provide specific information.

There does not appear to be any reason why an in-house benefits tracking program would be more cost-effective than one performed by a contractor, or vice versa. The decision on this should be based on cost and staff availability criteria.

Some sort of automated data handling capability is definately required for benefits tracking. The MANTECH Division is exploring this under a separate contract. We doubt whether the existing MASIS and CAMIS systems to which MANTECH has access can be cost-effectively exploited for benefits tracking. We assessed these systems, as well as the new management information systems that have recently been implemented by the Army and the Navy MANTECH programs. We found CAMIS and MASIS as they are currently available to MANTECH to be adequate for a "bare bones" benefits tracking capability. However, they lack many desired features, are difficult to

P&WA MANTECH PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

PROJECT	STATUS OF THE TECHNOLOGY AT P&WA	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT P&WA	ESTIMATED P&WA SAVINGS THROUGH 1992 (IN 1982 $)
TI CASTING STANDARDS	EXTENSIVE IMPLEMENTATION FOR COMMERCIAL AND MILITARY ENGINES (10 DIFFERENT PARTS IN 5 MILITARY ENGINES; AND 5 DIFFERENT PARTS IN 2 COMMERCIAL ENGINES). MAJOR CONTINUING ADVANCES IN TI CASTING TECHNOLOGY WITH BROAD AND EXPANDING UTILIZATION IN AEROSPACE INDUSTRY.	1982	$161,300,000
NNS ISOTHERMAL FORGING	EXTENSIVE IMPLEMENTATION FOR COMMERICAL AND MILITARY ENGINES; IN100 AND TITANIUM ALLOY COMPONENTS (42 PARTS IN 4 MILITARY ENGINES; AND 13 PARTS IN 4 COMMERCIAL ENGINES).	1980	$117,500,000
HIP REJUVENATION AND REPAIR	IMPLEMENTED FOR F100 STAGE 1 TURBINE VANES. RESTORES 150% OF NEW PART LIFE; ALSO USED ON NEW VANES. EXPANDED IMPLEMENTATION IS LIKELY IN THE FUTURE.	1982	$ 99,600,000
JOINING TI ALLOYS (EB WELDING OF ROTORS)	BASELINE PROCESS FOR 1120 AND 1128 FAN ROTORS AND 2037 COMPRESSOR ROTORS. MORE APPLICATIONS LIKELY IN FUTURE.	1982	$ 35,200,000
RECLAMATION OF IN100	APPROXIMATELY 70% OF ALL IN100 IS NOW SUCCESSFULLY RECLAIMED FOR ENGINE USE.	1978-79	$ 17,800,000
NNS ULTRASONIC INSPECTION (2 PROJECTS)	3 INSPECTION SYSTEMS IN USE NOW; MORE ARE PLANNED. ALSO, THE TECHNOLOGY IS BROADLY UTILIZED BY VENDORS AND OTHER AEROSPACE MANUFACTURERS.	1976-78	$ 3,300,000
NICKEL BASE SUPER ALLOY TURBINE DISKS (AF2-1DA)	NOT IMPLEMENTED FOR DISKS, BUT .S BEEN IMPLEMENTED FOR J-58 COMPRESSOR TIE BOLTS. MAIN BENEFIT IS INCREASED CREEP RESISTANCE (I.E. INCREASED SERVICE LIFE).	1980	$ 45,000
ADVANCED COMPOSITE ENGINE STATIC STRUCTURE (GR/PI)	IMPLEMENTED FOR 1120 EXTERNAL EXHAUST NOZZLE FLAPS. MAIN BENEFITS ARE LOWER WEIGHT (7 LBS) AND IMPROVED DURABILITY.	1986	-
ADVANCED SANDWICH PANEL CONSTRUCTION	PROVEN TECHNICALLY EFFECTIVE FOR FLAT PANELS BUT COSTS HAVE NOT WARRANTED IMPLEMENTATION. SPF AND SPF/DB IS UNDER CONSIDERATION FOR SEVERAL ENGINE COMPONENTS.	-	-
CONSOLIDATION OF TI-6-4 POWDER TO NEAR-NET SHAPE	TECHNICALLY PROVEN BUT SMALL DOLLAR SAVINGS HAVE NOT INDUCED CHANGE.	-	-
DS EUTECTIC AIRFOILS	TECHNICALLY UNSUCCESSFUL. PURSUIT OF THIS TECHNOLOGY AT P&WA HAS STOPPED.	-	-
PRODUCTION OF TI ALLOY COMPRESSOR DISKS FROM POWDER BILLET	MAJOR TECHNICAL PROBLEMS REMAIN. CLEAN POWDER IS THOUGHT TO BE CURRENTLY UNPROCURABLE. ADVANCES IN COMPETING TI PROCESSES HAVE LESSENED THE NEED FOR THIS TECHNOLOGY.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 = $434,745,000

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
PRATT AND WHITNEY AIRCRAFT

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
GOVERNMENT PRODUCTS DIVISION							
Ti Casting Standards	.385	1976	1982	Mil savings mostly USAF	85.9	75.4	161.3
NNS Isothermal Forging	.412	1977	1980	Mil savings mostly USAF	77.5	40.0	117.5
HIP Rejuvenation and Repair	.280	1979	1982	99.6	99.6	-	99.6
Joining Ti Alloys (EB Welding Rotors)	.305	1975	1982	Mil savings mostly USAF	11.2	24.0	35.2
Reclamation of IN100	.700	1979	1978-1979	Mil savings mostly USAF	11.2	6.6	17.8
NNS Ultrasonic Inspection (2 Projects)	.439	1977	1976-1978	Mil savings mostly USAF	2.8	0.5	3.3
Nickel Base Superalloy Turbine Disks (AF2-1DA)	.293	1976	1980	.045	.045	-	.045
Advanced Composite Engine Static Structures (Gr/PI)	.285	1979	1986	T E C H N I C A L		B E N E F I T S	
Advanced Sandwich Panel Construction	.772	1975	-	-	-	-	-

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
Consolidation of Ti-6-4 Powder to Near-net Shape	.253	1978	-	-	-	-	-
DS Eutectic Airfoils	.743	1976	-	-	-	-	-
Production of Ti Alloys Compressor Disks from Powder Billet	.263	1976	-	-	-	-	-
P&WA SUBTOTAL	5.13	For Implemented Projects, Avg. Time to Impl = 3.8 Yrs		252.8	288.2	146.5	$434.7

General Dynamics Corporation

GENERAL DYNAMICS PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

PROJECT	STATUS OF THE TECHNOLOGY AT GENERAL DYNAMICS	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT GENERAL DYNAMICS	ESTIMATED GENERAL DYNAMICS SAVINGS THROUGH 1992 (IN 1982$)
FT. WORTH DIVISION			
COMPOSITES PRODUCTION INTEGRATION	EXTENSIVE IMPLEMENTATION FOR WING AND VERTICAL AND HORIZONTAL STABILIZER SKINS. A MAJOR CO. COMMITMENT HAS BEEN MADE TO FACILITIZE THIS TECHNOLOGY, AND UTILIZATION IS LIKELY TO EXPAND IN THE FUTURE FOR OTHER AIRCRAFT.	1980	$31.5 MILLION. WEIGHT SAVINGS ARE ALSO SUBSTANTIAL, AND LAMINATE QUALITY IS SUPERIOR TO HAND LAY-UPS.
RELAXED MFG. DESIGN TOLERANCE CONCEPTS	IMPLEMENTED FOR ALMOST ALL F-16 ALUMINUM MACHINED PARTS. LESSONS LEARNED WILL BE APPLIED TO ALL FUTURE AIRCRAFT.	1977	$30.6 MILLION
LOW COST MFG. USING ADVANCED COMPOSITE BROADGOODS	TECHNOLOGY IS ESSENTIALLY PRODUCTION READY, BUT NOT IMPLEMENTED. G.D. HAS IMPLEMENTED AUTOMATED LAPE LAYING INSTEAD. NO NEAR-TERM IMPLEMENTATION AT G.D. IS ANTICIPATED.	-	-
ACOUSTIC-ELASTIC FASTENER PRELOAD INDICATOR	TECHNOLOGY NOT YET PRODUCTION READY, NEAR-TERM UTILIZATION IN DOUBT DUE TO PROBABLE POOR COST-EFFECTIVENESS.	-	-
LOW COST TOOLING FOR ADVANCED COMPOSITE SHELL TYPE STRUCTURE	TECHNOLOGY IS NOT YET PRODUCTION READY, NOT IMPLEMENTED, AND NO PLANS TO DO SO IN NEAR FUTURE.	-	-
CONVAIR DIVISION			
FEEDBACK CONTROLLED SPOTWELDING	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED DUE TO LACK OF AN APPLICATION. BEING CONSIDERED FOR FUTURE USE.	-	-
FABRICATION & ASSEMBLY OF ADVANCED THERMOPLASTIC COMPOSITE PRIMARY AIRCRAFT STRUCTURE	MANTECH PROJECT WAS A TECHNICAL SUCCESS BUT NO INFO. COULD BE OBTAINED ON IMPLEMENTATION.	-	-
MFG. METHODS FOR METAL MATRIX STRUCTURAL COMPONENTS	MANTECH PROJECT WAS A TECHNICAL SUCCESS BUT NO INFO. COULD BE OBTAINED ON IMPLEMENTATION.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 - $62.1 MILLION

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
GENERAL DYNAMICS CORPORATION

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
Ft. WORTH DIVISION							
Composites Production Integration	.504	1980	1980	31.5	31.5	-	31.5
Relaxed Mfg. Design Tolerance Concepts	.623	1977	1977	30.6	30.6	-	30.6
Low Cost Mfg. Using Advanced Composite Broadgoods	.192	1975	-	-	-	-	-
Acoustic-Elastic Fastener Preload Indicator	.196	1978	-	-	-	-	-
Low Cost Tooling For Advanced Composite Shell Type Structure	.563	1975	-	-	-	-	-
CONVAIR DIVISION							
Feedback Controlled Spotwelding	.090	1976	-	-	-	-	-
Advanced Thermoplastic Composite Primary Aircraft Structure	.189	1975	-	-	-	-	-
Mfg. Methods for Metal Matrix Structural Components	.519	1976	-	-	-	-	-
GENERAL DYNAMICS SUBTOTAL	2.876	For Implemented Projects, Avg. Time to Impl = 0 Yrs		62.1	62.1	-	$62.1

Rockwell International

ROCKWELL INTERNATIONAL PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

PROJECT	STATUS OF THE TECHNOLOGY AT ROCKWELL	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT ROCKWELL	ESTIMATED ROCKWELL SAVINGS THROUGH 1992 (IN 1982$)
NORTH AMERICAN AVIATION OPERATIONS			
SUPERPLASTIC FORMING OF TITANIUM STRUCTURES	EXTENSIVE IMPLEMENTATION-APPROX. 76 B-1B PARTS AND 1 SPACE SHUTTLE COMPONENT. EXPANDING UTILIZATION AT ROCKWELL AND THROUGH-OUT AEROSPACE INDUSTRY.	1982	$35.9 MILLION. MAJOR WEIGHT SAVINGS APPROX 33%.
ADVANCED PRESS DIFFUSION BONDING	IMPLEMENTED FOR 5 B-1B COMPONENTS. EXPANDING UTILIZATION IN FUTURE AIRCRAFT IS LIKELY.	1982	$10.4 MILLION.
SUPERPLASTIC FORMING/DIFFUSION BONDING	IMPLEMENTED FOR PRODUCTION OF 1 B-1B STRUCTURE. FUTURE POTENTIAL IS EXTREMELY ATTRACTIVE.	1982	MAJOR COST SAVINGS, BUT CANNOT BE QUANTIFIED DUE TO LACK OF DATA. MAJOR WEIGHT SAVINGS--APPROX 30%.
PLASMA ARC WELDING I (BUTT WELDING)	IMPLEMENTED FOR PRODUCTION OF 2 B-1B STRUCTURES. FUTURE UTILIZATION POTENTIAL APPEARS VERY ATTRACTIVE.	1982	$5.5 MILLION.
PLASMA ARC WELDING II (ARC SEAM BURN-THROUGH)	TECHNICALLY READY, BUT NOT ECONOMICAL TO REPLACE EXISTING B-1 TOOLING. NO OTHER NEAR-TERM APPLICATIONS AT ROCKWELL.	-	-
LOW COST COMPOSITE WING/ FUSELAGE (INTEGRAL GR/EP COMPOSITE)	NOT IMPLEMENTED. INTEGRAL GR/EP COMPOSITE STRUCTURES WILL LIKELY BE IMPLEMENTED ON FUTURE MILITARY FIGHTERS.	1988-1990	-
ADVANCED MULTI-LAYER DRILLING	NOT FULLY TECHNICALLY READY FOR PRODUCTION USE. NOT IMPLEMENTED, AND NO PLANS TO DO SO IN NEAR FUTURE.	-	-
ROCKETDYNE			
INJECTION MOLDED PRECISION ROCKET ENGINE COMPONENTS	NOT IMPLEMENTED DUE TO PERCEIVED HIGH TECHNICAL RISK. NEAR-TERM IMPLEMENTATION NOT LIKELY.	-	-
MFG. METHODS FOR TAGN	PROJECT WAS A TECHNICAL SUCCESS, BUT NO INFO ON IMPLEMENTATION COULD BE OBTAINED.	-	-
ELECTRONICS RESEARCH DIVISION			
ADVANCED BUBBLE DOMAIN MATERIALS	TECHNICALLY SUCCESSFUL AND IMPLEMENTED BRIEFLY, BUT THEN DROPPED WHEN CO. GOT OUT OF THE BUBBLE DOMAIN MEMORY BUSINESS. NO NEAR-TERM PRODUCTION IS ANTICIPATED.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 - $51.8 MILLION

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
ROCKWELL INTERNATIONAL

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
NORTH AMERICAN AVIATION OPERATIONS							
Superplastic Forming of Titanium Structures	.191	1975	1982	35.9	35.9	-	35.9
Advanced Press Diffusion Bonding	.794	1977	1982	10.4	10.4	-	10.4
Superplastic Forming/Diffusion Bonding	1.014	1979	1982	COST SAVINGS	COULD NOT	BE QUANTIFIED	
Plasma Arc Welding I	.229	1975	1982	5.5	5.5	-	5.5
(Butt Welding)							
Plasma Arc Welding II (Arc Seam Burn Through)	.325	1978	-	-	-	-	-
Low Cost Composite Wing/Fuselage (Integral Gr/Ep Composite)	.896	1979	-	-	-	-	-
Advanced Multi-Layer Drilling	.124	1977	-	-	-	-	-
ROCKETDYNE							
Injection Molded Precision Rocket Engine Components	.244	1978	-	-	-	-	-
Mfg. Methods for TAGN	.492	1978	-	-	-	-	-

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
ELECTRONICS RESEARCH DIVISION							
Advanced Bubble Domain Materials	.265	1975	-	-	-	-	-
ROCKWELL SUBTOTAL	4.574	For Implemented Projects, Avg. Time To Impl = 5.5 Yrs (Due to B-1 program delay)		51.8	51.8	-	51.8

McDonnell Douglas Corporation

MCDONNELL DOUGLAS PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

:	STATUS OF THE TECHNOLOGY AT MCDONNELL DOUGLAS	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT MCDONNELL DOUGLAS	ESTIMATED MCDONNELL DOUGLAS SAVINGS THROUGH 1992 (IN 1982$)
:LL DOUGLAS ELECTRONICS CO.			
:D MFG. :ES FOR IDE PRINTED T BOARDS	IMPLEMENTED AT MCDONNELL DOUGLAS FOR PRODUCTION OF OVER 10,000 BOARDS TO DATE FOR F-15, CRUISE MISSILE, AND OTHER APPLICATIONS. WIDE IMPLEMENTATION ELSEWHERE FOR MISSILE, SPACE, RADAR, AND COMPUTER APPLICATIONS.	1978	NO COST SAVINGS. MANUFACTURING COSTS ARE HIGHER THAN FOR OTHER BOARDS. POSSIBLE OFFSETTING COST SAVINGS DUE TO REPAIR AVOIDANCE AND LOWER REPAIR COSTS CANNOT BE QUANTIFIED.
:LL AIRCRAFT CO.			
LASTIC G/DIFFUSION G	TECHNICALLY SUCCESSFUL. SPF NOW IMPLEMENTED FOR PRODUCTION OF 67 F-15 PARTS. BY 1992, 103 F-15 PARTS EXPECTED TO BE PRODUCED BY SPF. SPF USED TO LESSER EXTENT FOR F-18 AND AV-8B PARTS. SPF/DB NOT IMPLEMENTED AT MCDONNELL DOUGLAS, BUT EXPECTED TO BE IN THE FUTURE.	1980	$20.3 MILLION FOR F-15. ALSO MINOR WEIGHT SAVINGS.
UM ION DEPOSITION	WIDELY IMPLEMENTED AT MCDONNELL DOUGLAS AND ELSEWHERE FOR ALUMINUM COATING OF PARTS FOR F-15, F-18, AV-8B, COMMERCIAL AIRCRAFT, SPACE SHUTTLE, MISSILES, AND RADARS. PROBABLE USE IN ALL NEW AIRCRAFT IN FORESEEABLE FUTURE.	1978	DUE TO SCOPE OF IMPLEMENTATION AND COMPLEXITY OF ANALYSIS, IDENTIFICATION OF COST SAVINGS IS BEYOND PROJECT RESOURCES. HOWEVER, LARGE DOLLAR BENEFITS ARE BEING REALIZED.
'ST .TED ATION OF ITE URES	NOT IMPLEMENTED. TECHNOLOGY FOUND NOT SUITABLE FOR STRUCTURAL SHAPES FABRICATED IN PROJECT. MCDONNELL DOUGLAS IS PURSUING TECHNOLOGY FOR POTENTIAL USE IN PRODUCING ROCKET-RAMJET COMBUSTORS.	-	-
UALITY ST TITANIUM	TECHNICALLY UNSUCCESSFUL. MCDONNELL DOUGLAS HAS NOT PURSUED THIS TECHNOLOGY ANY FURTHER.	-	-
ELL DOUGLAS ASTRONAUTICS CO.			
ETHODS FOR MATRIX SING	PARTIAL TECHNICAL SUCCESS. NOT IMPLEMENTED. CENTRIFUGAL IMPREGNATION PROCESS SUPERSEDED BY SIMPLER PRESSURE PROCESS.	-	-
ICATION OF X SHAPED COMPOSITE MS	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED TO DUE TO ACCEPTABLE LOWER COST ALTERNATIVES.	-	-
AL ROCKET- CARBON- COMBUSTOR UP	TECHNICALLY NOT FULLY READY FOR PRODUCTION USE. NOT IMPLEMENTED AT MCDONNELL DOUGLAS. THE CARBON-CARBON PROCESSING PROCEDURE WAS LATER USED IN A USAF ASALM PROGRAM THAT WAS ULTIMATELY CANCELLED.	-	-
ETHODS FOR Y VEHICLE ED ITE UCTURE	TECHNICALLY UNSUCCESSFUL. MCDONNELL DOUGLAS HAS NOT PURSUED THIS TECHNOLOGY ANY FURTHER.	-	-
ETHODS OCESSING AVE CARBON MS	TECHNICALLY SUCCESSFUL, BUT MCDONNELL DOUGLAS HAS NOT IMPLEMENTED IT AND HAS NO PLANS TO DO SO IN THE NEAR FUTURE. MCDONNELL DOUGLAS REMAINS QUALIFIED AS A USAF SUPPLIER OF CARBON-CARBON MATERIALS.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 - $20.3 MILLION

SUMMARY OF MANUFACTURING COST SAVINGS
MCDONNELL DOUGLAS CORPORATION

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Projects costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
MCDONNELL DOUGLAS ELECTRONICS CO.							
Improved Mfg. Processes for Polyimide Printed Circuit Boards	.305	1977	1978	TECHNICAL BENEFITS			
MCDONNELL AIRCRAFT CO.							
Superplastic Forming/Diffusion Bonding	.670	1980	1980	20.3	20.3; Savings - Also for Non-USAF Engines, But Not Quantified		20.3
Aluminum Ion Vapor Deposition System	.371	1978	1978	MAJOR SAVINGS, BUT COULD NOT BE QUANTIFIED			
Low Cost Automated Fabrication of Composite Structures	.326	1977	-	-	-	-	-
High Quality Low Cost Ti Tubing	.320	1977	-	-	-	-	-

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
MCDONNELL DOUGLAS ASTRONAUTICS CO.							
Mfg. Methods for Resin Matrix Processing	.297	1976	-	-	-	-	-
Densification of Complex Shaped Woven Composite Preforms	.539	1975	-	-	-	-	-
Integral Rocket-Ramjet C-C Combustor Scale-Up	.450	1979	-	-	-	-	-
RV Advanced Composite Substructure	.875	1978	-	-	-	-	-
Processing Fineweave Carbon Preforms	.170	1978	-	-	-	-	-
MCDONNELL DOUGLAS SUBTOTAL	4.323	For Implemented Projects, Avg. Time To Impl = .3 Yr		20.3	20.3	-	$20.3

SUMMARY OF TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED PROJECTS

GENERAL ELECTRIC

1. Large Superalloy Castings Using Segmented Molds.

   a. Not cost effective vs existing methods for intended application.
   b. Attractiveness reduced by advances in integral casting processes.
   c. Low potential for future implementation.

2. Pressure Bonding of Shrouded Blades and Vanes.

   a. Not cost effective vs existing method for intended application.
   b. Leading candidate for future production of engine fan blisks.
   c. Strong potential for future implementation.

3. Manufacturing Methods for MNOS Memory Arrays.

   a. Met general objectives; some specific objectives were relaxed.
   b. Eclipsed by developments in alternate technology.
   c. No potential for future implementation.

PRATT & WHITNEY

1. Manufacturing Methods for Advanced Sandwich Panel Construction.

   a. Not cost effective vs existing methods for intended application.
   b. Being considered for future production of engine components.
   c. Some potential for future implementation.

2. Consolidation of Blended Elemental Ti-6Al-4V Powder to Near-Net Shape.

   a. Not cost effective vs existing methods for intended application.
   b. Available for more cost effective high volume application.
   c. Some potential for future implementation.

GENERAL DYNAMICS

1. Low Cost Manufacturing Using Advanced Composite Broadgoods.

   a. Was cost effective vs existing metal production methods.
   b. Eclipsed by alternate composite production method.
   c. No potential for future implementation.

2. Feedback Controlled Spotwelding.

   a. No applications available at General Dynamics for implementation.
   b. Being considered for re-conditioning of Atlas missiles.

APPENDIX B

SUMMARY OF TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED PROJECTS

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
SUMMARY FOR ALL PROJECTS

All $ are in 1982$, except where noted otherwise, in $1,000,000s

	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
ALL PROJECTS	32.59* 52.675	For 35 Implemented Projects, Avg. Time To Impl = 3.3 Yrs		$522.08	$592.93	$399.45	$992.38
RATIO OF SAVINGS TO PROJECT COST (both in 1982$)	-	-	-	10:1	11:1	8:1	19:1

*denotes nominal $

Summary For All Contractors

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
HUGHES AIRCRAFT COMPANY

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
Detector Grade Intrensic Silicon	.553 USAF .362 ARMY	1978	-	ESTABLISHED A DOMESTIC SOURCE			
Impatt Diodes	.275	1974	1975-1976	2.73	2.73	-	$2.73
X-brand TR Limiters	.413	1976	1979	6.89	14.4	-	$14.4
Fluxless Al Brazed Antenna	.592	1977	-	-	-	-	-
Full Wafer LSI	.325	1976	-	-	-	-	-
HUGHES SUBTOTAL	2.52	Implemented For, Avg. Time To Impl = 1.0 Yrs		9.58	17.13	-	$17.13

HUGHES PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

OJECT	STATUS OF THE TECHNOLOGY AT HUGHES	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT HUGHES	ESTIMATED HUGHES SAVINGS THROUGH 1992 (IN 1982 $)
NUFACTURING THODS PROGRAM R IMPATT DIODES	TECHNICALLY SUCCESSFUL. WIDELY IMPLEMENTED IN NEW LINE OF MILITARY COMMUNICATIONS AND TEST EQUIPMENT OPERATING AT FREQUENCIES ABOVE 75 GHZ. PROJECT RESULTS RAPIDLY ACCELERATED DEVELOPMENT AND IMPLEMENTATION OF THIS EQUIPMENT.	1974	$2.7 MILLION DUE TO MANUFACTURING COST SAVINGS. ALSO LARGE BUT UNQUANTIFIABLE DOLLAR SAVINGS RESULT FROM IMPROVED LIFETIME AND RELIABILITY.
NUFACTURING THODS PROGRAM IR X BRAND TR MITERS	TECHNICALLY SUCCESSFUL. MANUFACTURING COSTS ESSENTIALLY THE SAME AS FOR PREVIOUS DESIGN, BUT LARGE DOLLAR SAVINGS DUE TO LOWER FAILURE RATES OF NEW LIMITERS AND, MORE IMPORTANTLY, LOWER FAILURE RATES OF RECEIVER FRONT ENDS FOR F-15, F-14, AND F-18 RADAR SYSTEMS.	1978	$14.4 MILLION DUE TO AVOIDANCE OF REPAIR COSTS FOR LIMITERS AND RADAR RECEIVER FRONT ENDS. INSUFFICIENT DATA TO MONETIZE ADDITIONAL SAVINGS DUE TO AVOIDED EQUIPMENT REMOVAL, SHIPPING, AND REINSTALLATION.
ANUFACTURING ETHODS FOR ETECTOR GRADE NTRINSIC ILICON	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED DUE TO DRASTIC DROP IN PRICE OF THIS MATERIAL FROM EXISTING FOREIGN SOURCE SHORTLY AFTER MATERIAL BECAME AVAILABLE FROM HUGHES.	-	NO DEFINITE MONETARY BENEFITS IDENTIFIABLE, SINCE PROJECT RESOURCES WERE INSUFFICIENT TO VERIFY THAT LARGE DROP IN MATERIAL PRICE WAS DUE TO ITS NEW DOMESTIC AVAILABILITY AT HUGHES.
ULL WAFER ARGE SCALE NTEGRATION (LSI) ODULE APPLICATION	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED DUE TO USE OF OTHER COST EFFECTIVE TECHNOLOGY.	-	-
LUMINUM FLUXLESS RAZED ANTENNA ANUFACTURING ETHODS PROGRAM	NOT TECHNICALLY SUCCESSFUL DUE TO UNRESOLVED PROBLEMS ASSOCIATED WITH NON-HOMOGENEOUS COMPOSITION OF ALUMINUM SHEET STOCK USED.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 = $17.1 MILLION

Hughes Aircraft Company

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
BOEING AEROSPACE CO.							
Airborne High Voltage Power Supplies	.330	1978	-	-	-	-	-
BOEING SUBTOTAL	2.928	For Implemented Projects, Avg. Time To Impl = 4 Yrs		-	-	.350	$ .350

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
THE BOEING COMPANY

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
BOEING COMMERCIAL AIRPLANE CO.							
Brazed Ti Hybrid Structures	.424	1976	1980	-	-	.350	.350
Multi-Layer Fastening Systems	.614	1976	1980	-	-	Savings but could not be quantified	-
High Integrity Forgings of Al & Ti Alloys	.590	1977	-	-	-	-	-
Multi-Axis Laser Cutting	.112	1975	-	-	-	-	-
Cutting Al Alloys with a 6-kW Laser	.025	1977	-	-	-	-	-
Dimensional Evaluation of Tapered Fastener Systems	.200	1977	-	-	-	-	-
Low Cost Composite Wing/Fuselage Manufacturing	.564	1979	-	-	-	-	-
BOEING MILITARY AIRPLANE DEVELOPMENT DIVISION							
Computer Aided Mfg. Architecture - Task III, Sheet Metal Fabrication Technology	.069	1977	-	-	-	-	-

BOEING PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

PROJECT	STATUS OF THE TECHNOLOGY AT BOEING	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT BOEING	ESTIMATED BOEING SAVINGS THROUGH 1992 (IN 1982 $)
BOEING COMMERCIAL AIRPLANE COMPANY			
MANUFACTURING METHODS FOR BRAZED TITANIUM HYBRID STRUCTURES	TECHNICALLY SUCCESSFUL. ONE IMPLEMENTATION TO DATE FOR THE BOEING-757 APU PLENUM FLOOR. LOWER-COST ALTERNATIVE TECHNOLOGIES MAY LIMIT FURTHER POTENTIAL APPLICATIONS.	1980	$.35 MILLION IN FUEL COSTS DUE TO WEIGHT SAVINGS. PROBABLY SUBSTANTIAL MANUFACTURING COSTS SAVINGS, BUT INFORMATION NOT READILY AVAILABLE.
MULTI-LAYER FASTENING SYSTEMS	ONE OF TWO DRILLING TECHNOLOGIES DEVELOPED WAS SUCCESSFUL, BUT WAS NOT COST EFFECTIVE FOR B-1 PRODUCTION. PROJECT CHARACTERIZATION OF EFFECTS OF BURRS ON FASTENER SYSTEM PERFORMANCE LED TO RECOMMENDATION TO MINIMIZE OR ELIMINATE DESTACK AND DEBURR OPERATIONS, WHICH WAS IMPLEMENTED IN ASSEMBLY OF BOEING-767 WING SPARS.	1980	COST SAVING FROM AVOIDANCE OF DEBURR OPERATIONS IN WING SPAR ASSEMBLY CANNOT BE QUANTIFIED DUE TO LACK OF DATA.
HIGH INTEGRITY FORGINGS OF ALUMINUM AND TITANIUM ALLOYS	TECHNICALLY UNSUCCESSFUL.	-	-
MULTI-AXIS LASER CUTTING	TECHNOLOGY IS ESSENTIALLY PRODUCTION READY, BUT NOT IMPLEMENTED. POTENTIAL APPLICATIONS NOT EXTENSIVE OR GENERAL ENOUGH TO JUSTIFY IMPLEMENTATION EXPENSE.	-	-
FEASIBILITY OF CUTTING ALUMINUM ALLOYS WITH A 6-KILOWATT LASER	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED DUE TO IMPROVEMENTS IN EXISTING ALTERNATIVE TECHNOLOGY.	-	-
DIMENSIONAL EVALUATION OF TAPERED FASTENER SYSTEMS	TECHNICALLY SUCCESSFUL, BUT COMPUTERIZED MECHANICAL PROBE AND SOFTWARE DEVELOPED IN PROJECT NOT IMPLEMENTED DUE TO REDESIGN OF INTENDED C-5B WING APPLICATION AND DEVELOPMENT OF ALTERNATE CAPACITANCE PROBE AT LOCKHEED.	-	-
LOW COST COMPOSITE WING/ FUSELAGE MANUFACTURING	TECHNICALLY UNSUCCESSFUL. EFFORTS TO IMPROVE THIS TECHNOLOGY HAVE CONTINUED AT BOEING AND ELSEWHERE, ALTHOUGH THERE ARE NO CURRENT PRODUCTION APPLICATIONS FOR IT.	-	-
BOEING MILITARY AIRPLANE DEVELOPMENT DIVISION			
COMPUTER AIDED MANUFACTURING (CAM) ARCHITECTURE - TASK III SHEET METAL FABRICATION TECHNOLOGY	TECHNICALLY UNSUCCESSFUL. AVAILABLE INFORMATION WAS INSUFFICIENT TO CHARACTERIZE SHEET METAL FORMABILITY PROCESSES TO SUPPORT ICAM PROJECT OBJECTIVES. NEGATIVE RESULTS WERE BASIS FOR REDIRECTION OF SHEET METAL ICAM EMPHASIS.	-	-
BOEING AEROSPACE COMPANY			
MANUFACTURING TECHNOLOGY FOR AIRBORNE HIGH VOLTAGE POWER SUPPLIES	TECHNICALLY SUCCESSFUL, BUT NOT IMPLEMENTED TO DATE. DESIGN AND FABRICATION GUIDELINES PUBLISHED AS VOLUME II OF PROJECT REPORT AND DISSEMINATED IN A FOLLOW-ON PROJECT WILL PROBABLY LEAD TO FUTURE IMPLEMENTATION.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 - $.35 MILLION

The Boeing Company

MANTECH BENEFITS ANALYSIS OF PAST PROJECTS
SUMMARY OF MANUFACTURING COST SAVINGS
NORTHROP CORPORATION

Savings are in 1982$, from Implementation Yr + 1 through 1992, in $1,000,000s
Project costs are in nominal dollars, in $1,000,000s

Project Title	Project Cost	Year Completed	Year Implemented	USAF End Items	All Military End Items	Commercial End Items	Total
ELECTRONICS DIVISION							
Mfg. Methods For Miniature Radiation Hardened Plated Wire Memory	.616	1976	1983	49.4	49.4	-	49.4
AIRCRAFT DIVISION							
Advanced Aluminum Weldbond Mfg. Methods	.195	1976	1985	30.0	30.0	-	30.0
Environmental Durability of the Weldbond, FPL, & Pabst Joining Systems	.699	1979	1985			-	
Low Cost Mfg. Concepts of Advanced Primary Aircraft Structures (2 Projects)	.918	1977	-	-	-	-	-
Low Flow, Low Pressure Prepregs	.330	1979	-	-	-	-	-
NORTHROP SUBTOTAL	2.758	For Implemented Projects, Avg. Time To Impl = 7.3 Yrs		79.4	79.4	-	$ 79.4

NORTHROP PROJECTS - SUMMARY OF IMPLEMENTATION AND BENEFITS

PROJECT	STATUS OF THE TECHNOLOGY AT NORTHROP	YEAR OF INITIAL PRODUCTION IMPLEMENTATION AT NORTHROP	ESTIMATED NORTHROP SAVINGS THROUGH 1992 (IN 1982$)
ELECTRONICS DIVISION			
MFG. METHODS FOR A MINIATURE RADIATION HARDENED PLATED WIRE MEMORY	TECHNICALLY SUCCESSFUL. IMPLEMENTED (BY ROCKWELL) AS MEMORY UNIT IN MX MISSILE SYSTEM.	1983	$49.4 MILLION. MANUFACTURING SAVINGS FOR SENSE AMPLIFIERS ARE APPROX. $4.4 MILLION. OVERALL MX PROGRAM COST SAVINGS DUE TO 15-POUND WEIGHT SAVING PER MISSILE ARE APPROX. $45 MILLION.
AIRCRAFT DIVISION			
ADVANCED ALUMINUM WELDBOND MFG. METHODS	TECHNICALLY SUCCESSFUL. IMPLEMENTED AFTER SCALE-UP WORK IN A FOLLOW-ON PROJECT.	1985	SAVINGS FOR THIS TECHNOLOGY GIVEN IN FOLLOW-ON PROJECT BELOW.
ENVIRONMENTAL DURABILITY OF THE WELDBOND, FPL, AND PABST JOINING SYSTEMS	IMPLEMENTED ON TEST-FLIGHT BASIS FOR FAIRCHILD A-10 FUSELAGE PANELS. NORTHROP COMMITTED TO IMPLEMENTATION FOR F-20 VERTICAL STABILIZERS. ALSO BEING CONSIDERED FOR F-20 FUSELAGE AND WING COMPONENTS. CANDIDATE FOR FUTURE IMPLEMENTATION FOR ATF.	1985	$30 MILLION. WEIGHT SAVINGS O APPROX. 25%.
LOW COST MFG CONCEPTS OF ADVANCED PRIMARY AIRCRAFT STRUCTURES	PARTIAL TECHNICAL SUCCESS. NOT IMPLEMENTED, BUT PROMISING APPROACHES EXPLORED IN THIS PROJECT WERE FURTHER DEVELOPED IN THE FOLLOW-ON PHASE II PROJECT.	-	-
LOW COST MGF. CONCEPTS OF ADVANCED PRIMARY AIRCRAFT STRUCTURES PHASE II.	TECHNICALLY SUCCESSFUL. NOT IMPLEMENTED, BUT THIS TECHNOLOGY IS A CANDIDATE FOR FUTURE USE IN PRODUCTION OF THE NORTHROP ATF.	-	-
LOW FLOW, LOW PRESSURE PREPREGS	TECHNICALLY UNSUCCESSFUL. NOT IMPLEMENTED, AND NO PLANS FOR IMPLEMENTATION IN THE NEAR FUTURE.	-	-

TOTAL ESTIMATED SAVINGS THROUGH 1992 - $79.4 MILLION

Northrop Corporation

c. Production system being marketed by Pertron Controls Corp.
d. Used to produce Fairchild A-10 panel sections for field testing.
e. Baseline process for Northrop A-20 vertical stabilizers.
f. Strong potential for future implementation.

3. Manufacturing Methods for Metal-Matrix Structural Components.

a. No information available on implementation of this process.
b. Potential for future implementation is unknown.

ROCKWELL INTERNATIONAL

1. Plasma Arc Welding II.

a. High cost savings vs existing method; tooling already sunk for intended application, so change not justified.
b. Very few airframe requirements for this process.
c. Eclipsed by developments in aluminum and composite technologies.
d. Little or no future potential for implementation.

2. Injection Molded Precision Rocket Engine Components.

a. High potential cost savings in production of large quantities of small complex components.
b. Perceived high technical risk and cost of reducing risk.
c. Potential for future implementation is unknown.

3. Manufacturing Methods for Triaminoguanidine Nitrate (TAGN).

a. No information available on implementation of this process.
b. Potential for future implementation is unknown.

4. Manufacturing Methods for Advanced Bubble Domain Materials.

a. Process briefly implemented commercially, then dropped by Rockwell.
b. Eclipsed by developments in alternate memory technologies.
c. Little or no potential for future implementation.

MCDONNELL DOUGLAS

1. Densification of Complex Shaped Woven Composite Preforms.

a. Not cost effective vs existing methods for intended application.
b. Some potential for future implementation.

2. Manufacturing Methods for Processing Fineweave Carbon Preforms.

a. No applications available or anticipated by McDonnell Douglas.
b. Potential for future implementation is unknown.

NORTHROP

1. Low Cost Manufacturing Concepts of Advanced Primary Aircraft Structures (2 projects).

   a. High potential cost savings from these manufacturing methods.
   b. Candidate for future use in Advanced Tactical Fighter production.
   c. Strong potential for future implementation.

BOEING

1. Multi-Axis Laser Cutting.

   a. Available applications not extensive or general enough.
   b. Potential for future implementation is unknown.

2. Feasibility of Cutting Aluminum Alloys with a 6-Kilowatt Laser.

   a. Eclipsed by developments in alternate technology.
   b. No known potential for future implementation.

3. Dimensional Evaluation of Tapered Fastener Systems.

   a. Need drastically reduced by redesign of intended application.
   b. Also eclipsed by developments in alternate technology.
   c. No known potential for future implementation.

4. Manufacturing Technology for Airborne High Voltage Power Supplies.

   a. Slow acceptance of technology because Mil Specs not yet prepared for testing and acceptability criteria.
   b. Follow-on contract for dissemination of technology to suppliers.
   c. Strong potential for future implementation.

HUGHES

1. Manufacturing Methods for Detector Grade Intrinsic Silicon.

   a. Lack of demand for product and drop in price from foreign supplier.
   b. Potential applications moving to use of other technologies.
   c. Little or no potential for future implementation.

2. Full Wafer Large Scale Integration (LSI) Module Application.

   a. Design changes in intended application incorporated other cost effective technology.
   b. No known potential for future implementation.

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